ILLUMINATING ENGINEERING

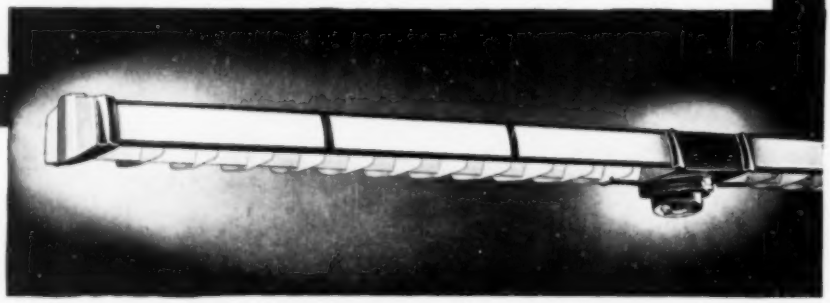
APRIL, 1949

Illuminating Art Objects and Pictures
Lighting in Dry - Cleaning Industry
Street Lighting Maintenance
Restaurant Illumination
Brightness Engineering
Cove Lighting

THE JOURNAL OF THE ILLUMINATING ENGINEERING SOCIETY

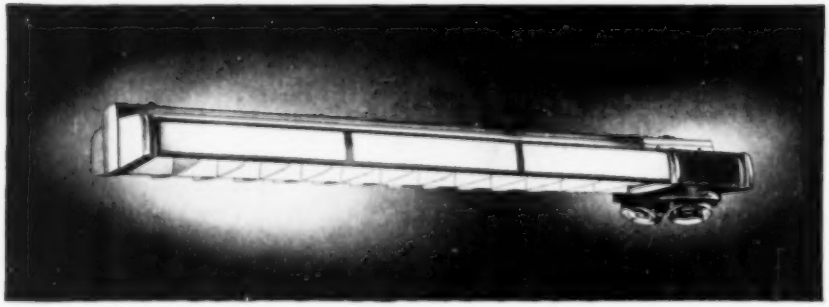
Grenadier "Spots"

In any installation where "spot" lighting and general lighting are desirable, you can recommend the Wakefield Grenadier "Spots" to do the double job with complete confidence. To all the proved advantages of the regular Grenadier has been added the plus advantage of an excellently designed spotlight assembly. Wakefield Grenadiers are finely engineered louvered units with translucent white plastic side panels. All metal parts are beautifully finished in soft metallic satin. For complete details on Grenadiers and the entire Wakefield line, you should have our fully illustrated, factually written, 36-page catalog. Write for your copy today.



THE GRENADIER II "SPOT"

Takes two 40W fluorescent lamps in each 4' section. Each 4' section has a single adjustable "spot" taking a 150W Sealed-Beam lamp.



THE GRENADIER IV "SPOT"

Takes four 40 W fluorescent lamps in each 4' section. Each 4' section has two adjustable "spots", each taking a 150 W Sealed-Beam lamp.

Wakefield Over-ALL Lighting

FOR OFFICE • DRAFTING ROOM • STORE AND SCHOOL

YOU CAN BE **SURE**.. IF IT'S

Westinghouse

PUSH CONTACT
TWIN LAMP HOLDER

Key to Added Safety-Added Strength

IN WESTINGHOUSE INDUSTRIAL FIXTURES

New Push-Contact Twin Lamp Holders increase fixture quality—without increasing the price. Available now—as a standard Westinghouse Industrial Luminaire feature—they offer industries 6 maintenance-cutting advantages.

An all-steel housing eliminates socket breakage and chipping. Spring-type sockets, with beveled ring guides, are used at both ends of the fixture to make positioning and insertion quick, safe, and simple. Spring pressure at both ends of the lamp provides a "floating ride" for the lamps. They can't fall out—regardless of shock or vibration. Sliding action of spring contacts assures a safe, positive electrical contact. Starters, housed in the Lamp Holder, may be changed without removing lamps. An arrow indicates the lamp the starter operates. Smooth, one-piece construction allows easy, fast cleaning.

For complete information about the new Westinghouse line of Industrial Luminaires, featuring the Push-Contact Twin Lamp Holder, write for Booklet B-4194. Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pa.

J-04237

Westinghouse

PLANNED LIGHTING PAYS

The Illuminating Engineer

Partners
in planned lighting

The Graybar Lighting Specialist

You of the Illuminating Engineering Society are outstanding in your knowledge of the *science* of lighting – the technical aspects – the engineering of efficient illumination.

Lighting personnel of the Graybar Electric Company are outstanding in their knowledge of the *business* of lighting – the selection, sale, and delivery of the best lighting equipment and lamps for any job. As distributor of the lighting products of many of the nation's leading manufacturers, Graybar has the *biggest selection of lamps and lighting units available anywhere.* Graybar experience dates all the way back to Edison's invention of the light bulb; it includes work on every type of lighting installation.

Thus Graybar is both qualified and anxious to cooperate with you in providing the best lighting for everyone. Whenever you want information on what is available to do a particular job you have in mind, our nearest office will welcome your call. *Graybar Electric Co., Inc. Executive offices: Graybar Bldg., New York 17, N. Y.*

4941

In addition to a complete selection of fixtures and G-E lamps for industrial, commercial, or residential lighting, indoors and out, Graybar can supply all the necessary wire, conduit, switches, ballasts, and other supplies – plus all the tools to put them in!

Everything Electrical for Planned Lighting via GraybaR

IN OVER 100 PRINCIPAL CITIES

ILLUMINATING ENGINEERING

THE JOURNAL OF THE ILLUMINATING ENGINEERING SOCIETY

APRIL
1949

Vol. XLIV
No. 4

Keeping the Street Lights Bright — L. J. Schrenk, R. T. Lattin, and F. H. Bollens — 193
Natural and Artificial Sunlight; Their Application in Testing Materials — A. H. Taylor — 201
Methods of Illuminating Art Objects and Pictures — Thomas S. Kelly — 204
Lighting Data Sheet—Series XIV Lighting of a Tower (25-19) — 211
Planned Restaurant Lighting — Maurice W. Ross — 212
What Is Comfortable Lighting? — L. C. Kalff — 215
Inspection Lighting for the Dry-Cleaning Industry — J. F. Finn — 218
The New Approach to Room Lighting — Parry Moon — 221
Important Concepts Underlying Lighting for Critical Seeing — Matthew Luckiesh — 226
Lighting Data Sheet—Series XIV Lighting a Kitchen Laundry (22-14) — 231
Engineering Aspects of Cove Lighting Design — L. C. Brown and J. R. Jones — 233
Miscellaneous Short Items
Modern Lighting for a Modern Living Room, 203; An Example of the "Leisure" Type of Restaurant, 214; Lighted Alcove for Arranging Flowers, 217; Lighting the Interior of a Jewelry Store, 225
TELECAST—Lighting News of Current Interest — 241
Sustaining Members — 251
I.E.S. Publications — 10A
Index to Advertisers — 16A

G. Ross Henninger
Editor
Ruby Redford
Production Editor

Clayton E. Ellis
Advertising Manager

Publication Committee
E. C. Huerkamp, Chairman
Berlon C. Cooper
H. H. Magdsick
R. W. McKinley
Richard G. Slauer
Rudolf W. Staud
Francis I. Wilson

STATEMENTS and opinions in articles and papers in **ILLUMINATING ENGINEERING** are the expressions of contributors and do not necessarily represent the policies or opinion of the Society. Official Society opinions are expressed only in official committee reports specifically approved by the Council. Correspondence is invited on all controversial matters.

Published Monthly by the

ILLUMINATING ENGINEERING SOCIETY

A. D. Hinckley
Executive Secretary

Founded 1906

C. L. Crouch
Technical Director

PUBLICATION office 32d Street & Elm Avenue, Baltimore, Md.

EDITORIAL and advertising offices 51 Madison Ave., New York 10, N. Y.

ILLUMINATING ENGINEERING. The Journal of the Illuminating Engineering Society. Copyright 1949 by the Society. Published monthly in the United States of America. Entered as second-class matter at the Post Office, Baltimore, Md. Acceptance for mailing at special postage rates provided for in Section 1103 P.L.&R., Act of October 3, 1917. Authorized July 16, 1918. †Subscription $10 per year plus extra postage to all countries to which second-class postage rates do not apply; single copies $1.50. ‡Address changes must be received at IES headquarters by the first of the month to be effective with the issue of the next succeeding month.

LIGHTING DATA SHEETS OF GENERAL LIGHTING PRACTICE

The first seven sheets of Series XIV, I.E.S. Lighting Data Sheets will be ready for mailing within the next few weeks. As limited quantities of each sheet are being printed, it is urged that subscriptions be placed early. Described in a news article in this issue, this series includes 24 sheets, the balance being mailed to subscribers during the remainder of the year. Typical data sheets on the subject of outdoor and residential lighting appear on pages 211 and 231 of this issue.

They represent real solutions to 24 practical lighting problems!

While each sheet will be printed in ILLUMINATING ENGINEERING, the series also is printed on extra-heavy coated paper and punched for binders for service in the field or on the reference shelf. The entire series of 24 sheets may be ordered now at $1.25 for single subscription; $1.00 in lots of 25 or more sets.

A new-style, durable loose-leaf binder to hold the data sheets is now in production. The binder will be attractively bound in blue fabrikoid (to match your I.E.S. Handbook) and stamped in gold. Rings are of 1" capacity, ample to hold Series XIV, and earlier or future sheets as well. Binders are priced singly at $1.50; $1.25 in lots of 25 or more.

Our supply of Series XIII is being replenished so if you missed the last series you may now provide yourself or your office with complete portfolios of practical lighting information. Series XIII is available at the old price of $1 per set.

Please place your order for data sheets and binders early.

ILLUMINATING ENGINEERING SOCIETY
51 Madison Avenue
New York 10, N. Y.

Date _____

Please enter subscriptions for Lighting Data Sheets, as follows:

_____ Sets Series XIV at $\frac{\$1.25}{\$1.00}$ per set; Total _____

_____ Sets Series XIII at $1.00 per set; Total _____

And our order for:

_____ Data Sheet Binders at $\frac{\$1.50}{\$1.25}$ each; Total _____

Our Order Number _____ Cash, Check or Money Order enclosed. Amount _____

Send Data Sheets to: _____

Address _____

City _____ *Zone* _____ *State* _____

Please Send bill to: _____

Address _____

City _____ *Zone* _____ *State* _____

Signature _____

Keeping the Street Lights Bright

By LOUIS J. SCHRENK,
ROBERT T. LATTIN and FRED H. BOLLENS

The purposes of this paper are to create a greater interest in maintaining street lighting systems, and to give to other municipalities and utilities the benefit of Detroit's experience. It discusses maintenance organization, lamp characteristics, luminaires, burning hours, and replacement schedules and the reasons for their arrangement. It also describes maintenance equipment and schedules, cleaning and repair methods through the annual seasons, and various testing procedures. The benefits of good street lighting maintenance in Detroit are summed up and shown to result in good public relations.

EXPERIENCE properly interpreted teaches us better ways to do things. At the Public Lighting Commission in Detroit we have had considerable experience with the business of maintaining a large number of street lights in good operating condition. Circumstances have been favorable for the trial and extended use of a number of practices tending to increase the efficiency of maintenance work where the principal object is to keep all luminaires in operation with a minimum loss of light value from any cause, whether it be dirt, breakages, burn outs, or service failures. Our secondary aim in efficient maintenance is to discover guides to better designs for new installations.

Good engineering calls for an acceptable allowance for operating depreciation of luminaires and lamps below the initial installation light values. But engineering demands and public reaction have become more critical than in the old days of dirty radial wave reflectors and birds' nests in the luminaires. Common sense indicates plainly the folly in designing a street lighting system for 10,000-lumen lamps in accordance with the "American Standard Practice for Street and Highway Lighting" and then permitting careless maintenance to allow a reduction in light output of 40 to 50 per cent, or to the level of a well maintained 6000-lumen unit.

It is here our hope to extend to others some knowledge of Detroit's successful luminaire maintenance experience, so that other applications of these methods may be made, perhaps with even greater success.

We will present some brief data on Detroit's street lighting units, and follow with a series of separate accounts describing some of our maintenance problems and how we solve them.

A paper presented at the National Technical Conference of the Illuminating Engineering Society, Boston, Mass., September 20-24, 1948. Messrs. SCHRENK, LATTIN, and BOLLENS are connected with the Public Lighting Commission, City of Detroit, Michigan.

Street Lighting System Data

The complete system from generating plant to luminaire is owned by the Public Lighting Commission, a chartered department of the corporation of the City of Detroit.

Street lighting units in service	42,000

Figures 1, 2, and 3. Left, Seagrave ladder; center and right, platform trucks, with 24 and 33 feet maximum elevation, respectively.

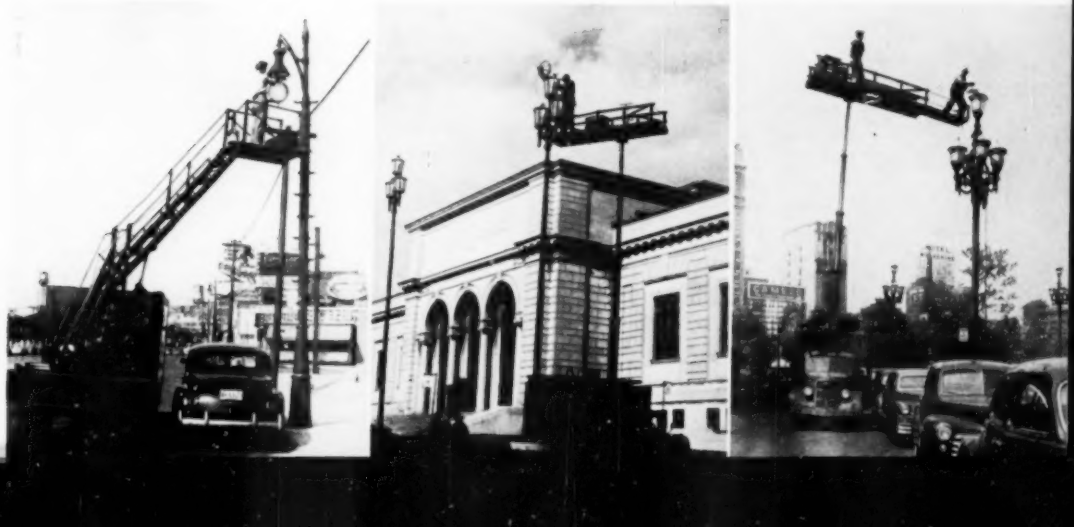


Figure 4. Group of ladder and platform trucks.

Of these approximately 45 per cent have underground power service, and 55 per cent have overhead power service. Average light output per unit . . . 7,843 lumens.

There are 14 different types of luminaires in use, and of these approximately 33 per cent have light distribution control, using refractors, reflectors, or a combination of both. The reflectors are of aluminum, with Alzak surface. Most of the downtown multiple units are of 1500-watt rating on double bracket standards. These units do not have controlled light features, since they are for white-way lighting in a main business section.

Main thorofares have 10,000- or 15,000-lumen units with reflectors and deflectors for light control. Some outlying highways have 6000-lumen units with refractor control.

In general, the mass of residential and outlying units are of 6000-lumen rating without control. There are a few 4000-lumen units. Since 1941, most new residential installations have been made with a new type of 6000-lumen fixture which has light control by a combination of reflector and refractor. Four-way beam fixtures are used at intersections and two-way beam fixtures between intersections. This type of unit has many advantages, and its use will be extended. (See ILLUMINATING ENGINEERING, Vol. XXXVI, No. 12, pages 1219 to 1245, Dec. 1941.)

All but a few exceptions of the 42,000 street lighting lamps are served by individual isolating transformers from a 6.6 ampere series circuit. The exceptions amounting to less than 2.5 per cent include the downtown 120-volt multiple white-way lighting; a small group of straight series 20 ampere bridge lamps; a few of the 4000-lumen units on group series transformer; and some old 1000-lumen units in an overhead alley light circuit and in a special residential underground circuit of early private installation. There are also a small number of ornamental bridge cluster lights on series-multiple transformers.

The series lamps operate at 20 amperes. This type of lamp includes approximately 94 per cent of the total number of units. Series 4000-lumen units operate at 15 amperes. Both 2500-lumen and 1000-lumen lamps, almost entirely in alley luminaires, operate at 6.6 amperes.

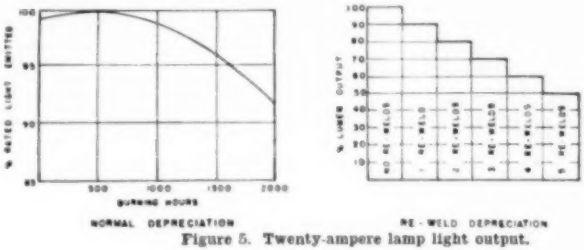


Figure 5. Twenty-ampere lamp light output.

The Lamp Room

All work required for the original installation, as well as operating replacements and maintenance of street lighting fixtures, is handled by the department's division known as the Lamp Room. The field force of 18 men and nine trucks operates under the direction of the foreman of street lighting maintenance, assisted by his two clerks and a field foreman. There is a force of five men in the Lamp Room shop who do the work of lamp and fixture preparation, testing, and repair, and repair of some circuit control equipment, such as relays.

Complete records of all luminaire locations are kept in the Lamp Room office in a file containing a card for each location. On this card is noted the date of original installation of the luminaire, its type, and later replacement, if any. Dates of outages are noted on these cards, and included in the value of the card is their use in court cases as evidence of lighting condition. Operation and maintenance schedules are controlled by the Lamp Room, in conformance with general policies.

Twenty-Ampere Lamp Characteristics. More than 94 per cent of series circuit luminaires use the standard 20-ampere 2000-hour lamp. With carefully controlled current, this lamp will emit 90 per cent of its original lumen rating at the end of 2000 burning hours. Burning characteristics of this lamp have been carefully checked for a number of years, and the average 2000 hour life cycle of a large number of such lamps in service has been well charted.

Loss of emitted light through the cycle is caused by the blanketing effect of filament evaporation condensing in a black deposit on the inside of the bulb. In some lamps this evaporation takes place early in the cycle. In others it is delayed, and burn-out is delayed in proportion. Many lamps are still in quite good condition after 2000 hours.

As the lamp reaches the end of its normal life cycle, the filament develops thin spots, where the temperature increases. In time the wire will melt and flow, shorting out one turn of the filament coil, without opening the circuit. This is called a re-weld, and each one reduces the light output of the filament by approximately 10 per cent of the original value. These spots remain quite brittle.

Visual inspection by trained men of an average group of 100 lamps returned from 2000 hour service will show 70 with no re-welds, 20 with one, and 10 with two or more re-welds. The best of the 70 lamps with no re-welds are saved for out-of-schedule replacements due to early burn-outs or damage of any kind. The early burn-outs amount to approximately 10 per cent, and damage replacements an additional five per cent.

Normal light depreciation for lamps going through the cycle without burn-out or re-welds is shown by the left hand curve on Fig. 5.

Loss in filament light emission due to re-welds is shown in the diagram at the right of the curve. As a lamp goes through its cycle, its light emission curve would be shown by a line similar to the normal curve, minus 10 per cent for each re-weld.

Application of re-weld percentage losses to an average group of 100 returned lamps will show nearly 90 per cent emission average at the end of the life cycle.

These figures will vary slightly for different ratings of lamps, but it does indicate the great care which is exercised in the selection of lamp bulbs.

Lamp Burning Hours and Replacement Schedules

The 4000 annual street light burning hours in Detroit are divided into 100 hour periods beginning January 1, and numbered from 1 to 80 to cover two years. The shortest periods, near the middle of winter, have seven calendar days, and the longest mid-summer periods have as many as 12 calendar days. The two-year schedule is used so that work can be planned sufficiently in advance.

In certain outlying districts where ordinarily a 4000-lumen unit would be used, and where the air conditions are good, advantage is taken of the opportunity to operate some 6000-lumen units at reduced current so they will equal a 4000-lumen unit at full current, and thereby make possible a 4000-hour lamp replacement and cleaning schedule. As soon as the district requires the 6000-lumen unit, it will only be necessary to operate the circuit at full current and maintain units on the 2000-hour schedule.

The lamps used for street lights are the manufacturer's standard product, rated at 2000 service hours. By maintaining the best field conditions of current value and protection in the luminaire, the laboratory life of 2000 hours is reached. Therefore the great bulk of lights in service must be replaced roughly twice in a year.

At the time of lamp replacement, the filament position in the luminaire is checked for correctness within $\frac{1}{8}$ inch. For this purpose a gauge is provided which enables the maintenance man to check adjustments of socket position quickly and accurately.

The new residential units with four-way or two-way distribution are checked by a sighting gauge to assure correctness of main beam position.

Operation breakage by rain, snow, or condensation in PS-40 lamps of the 10,000- and 15,000-lumen sizes was quite common. Now the use of bi-post lamps with hard glass eliminates most of such losses.

In addition to reducing damage by water, this

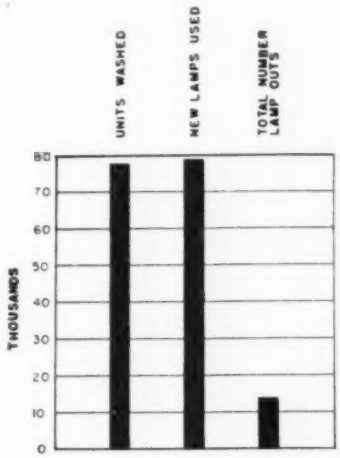
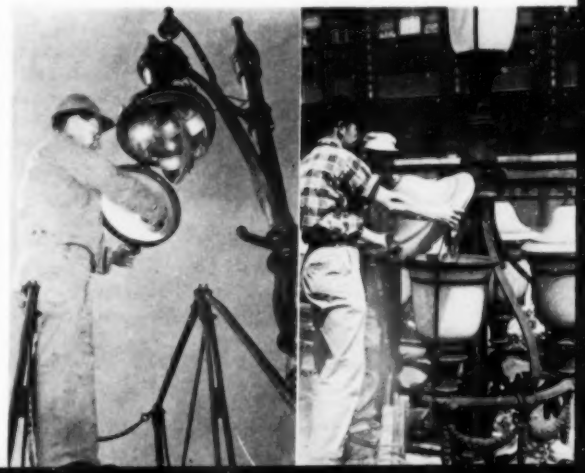


Figure 6. Above, Annual washings and lamps used for 42,000 luminaire maintenance; Figures 7 and 8, below, illustrate typical cleaning operations.



lamp provides more reliable operation without many of the characteristic failures of the larger PS-40 lamps, such as slow air leaks, lead-in failures, and liability to explosion. These explosions will sometimes nick or mar the reflectors. The collector screen reduces considerably the black deposit on the inside of the bulb, resulting in better lumen output maintenance. Also heat deterioration in the bi-post socket is much less than in the mogul socket.

Records of service failures show that the PS-40 10,000- and 15,000-lumen lamps had approximately four times as many failures in service as the bi-post lamps of the same ratings. It is felt that the extra cost of bi-post lamps and sockets is justified by their superior operating record.

Night Patrol

There are from five to eight trouble men on duty from 4:30 p.m. to midnight. Their principal duties include investigation of reports of the failures in the distribution system providing power to schools and public buildings, the municipal railway department, and to street lighting circuits. Where possible, they make temporary repairs. In the remaining time up to midnight, they make visual inspection for street light outages. Under this arrangement all lights on main thorofares are seen twice a week, and all in residential streets once a week. The trouble men replace all burned out lamps which they can reach by climbing the pole, or have time to service from ladder rigs. The rest are reported for service by the following day's crew.

Maintenance Schedules

The work of the maintenance crew includes cleaning and inspection of the luminaires, in addition to the lamp replacements described above.

Cleaning and inspection of all luminaires is controlled by a maintenance schedule based on our plan of holding light deterioration due to dirt at a maximum of 10 per cent. In general, the dirt accumulation will occur at a constant rate between cleanings, resulting in an average light loss of five per cent for each maintenance period. Reference again to the 20-ampere lamp light output depreciation shown on Fig. 1 will show that while the loss in filament emission amounts to 10 per cent at the end of the 2000-hour schedule, the loss takes place quite slowly in the first 1000 hours, and more rapidly in the last 1000 hours. Thus the average over the 2000 hours is somewhat less than five per cent. The two losses in light output of the luminaire will then total a maximum of 20 per cent in each maintenance area as it comes to the 2000 hour limit, at which time new cleaning and re-lamping will take place, and the average light loss for each area will be 10 per cent. The result is a city-wide over-all luminaire efficiency of 90 per cent.

After a considerable amount of experimenting, the city area was divided into districts with convenient boundaries and of such size that a maintenance crew will complete the work in from five to nine working days. Each section is numbered, and frequency of globe cleaning is designated in accordance with the nature of the district. In order to make normal lamp replacements fall at globe cleaning times, the maintenance schedules are also based on burning hours, although globe dirt deterioration continues daily around the clock. The maintenance schedule will repeat itself twice a year.

1000-hour maintenance was designated for the following:

All downtown areas.
Heavy manufacturing and railroad round house areas.
Manufacturing sections where air conditions are bad.

4000-hour maintenance was designated in the outlying residential sections mentioned previously where reduced current permits 4000-hour lamp life. In those sections, 4000-lumen lamps would ordinarily be used.

2000-hour maintenance was designated for all main traffic streets and the remaining areas, which include the bulk of the street lighting units.

Except in rare small districts with unusually bad air conditions, it has been found that the above cleaning schedule maintains luminaire light deterioration from glass and reflector dirt within the 10 per cent allowance.

Luminaire Cleaning: Inspection Procedure and Equipment

Seagrave Ladder. In order to clean and inspect properly in the field, the maintenance man must be able to have both hands free for work. This means he must stand on a firm and protected platform, and feel perfectly secure while moving around the luminaire.

Two types of motor vehicles are used for this work. One carries a Seagrave ladder (Fig. 1) on a platform at the back of the truck body. This type resembles a step ladder, with hand rails along the sides. At the top is a platform 2½ feet wide by 4½ feet long, protected by hand rails on three sides. The ladder folds down and rests on top of the cab and body when not in use. This ladder is shown in the photograph Fig. 1.

Platform Trucks. The other type of vehicle has a railing protected platform which raises vertically from the top of the truck body (Figs. 2 and 3). In both cases the raising is done hydraulically, with the pump being connected to the truck engine.

Turning of ladder or platform is done manually, so that a luminaire can be worked on over a parked car or other street obstruction. Two of the hoists will raise their platforms to a height of 24 feet, and a third will raise its platform to 33 feet. Platform types are shown in the photographs Figs. 2 and 3. Both ladder and platform types are shown in group photograph Fig. 4.

Each truck is equipped with a 40-gallon insulated tank. Hot water placed there in the morning will remain hot enough for use for twelve hours. In the truck body, space is provided for a supply of lamps, cleaning materials, and miscellaneous small repair parts sufficient for a day's work by the crew.

At present the department has nine of these trucks available for street lighting work. In an average year, three of them will have their time largely occupied with new installations or changes in connection with city-wide street lighting additions or improvements. The balance of time for these three will be filled in with replacements due to early burn-outs and willful or accidental breakages. This leaves an average of six trucks available for regular re-lamping, cleaning, and inspection.

Typical Cleaning Operations. The bulk of cleaning is done in the field, and typical cleaning operations are shown in photograph Figs. 7 and 8. In Fig. 7, the globe is lowered by swinging the holder down so that the globe can be sponged with a solution of tri-sodium phosphate in hot water, rinsed with clear water, and then dried with a clean sponge. The reflector is sponged off with clear water only and dried. Fig. 8 shows the glass hood of a white-way luminaire lifted for cleaning. Cellulose and wool sponges are used. Rubber gloves are provided for the men to use as desired.

This method of cleaning is satisfactory except in some manufacturing and railroad districts, where over a period of approximately three years a hard deposit will form which is impervious to field washing. Such glassware is brought in to the shop and given a muriatic acid bath, rinsed, and dried.

Special attention is also given to the condition of gaskets, sockets, wiring, and other fixture parts. Any worn out or defective items are replaced. After this maintenance attention has been given the unit, it is assumed that it will render trouble-free performance until the next regular service.

These cleaning methods have been found satisfactory. After ten years of service, enclosed aluminum reflectors are found to have retained 95 per cent of their original reflectivity.

Field cleaning with water during the extreme cold weather periods in winter is practically impossible. This fact, together with the reduced force caused by summer vacations, causes the cleaning schedule to have definite peaks in fall and spring, and valleys in midsummer and midwinter.

Dry cloth cleaning in the winter is only about 50 per cent effective. Experimental use has been made of a liquid dry cleaner known as "Cullenite," furnished by one of the fixture manufacturing companies. After application by a cloth, it is brushed vigorously until nearly dry. After it is dry the remaining powder is brushed off. The method is very effective, but takes considerable extra time.

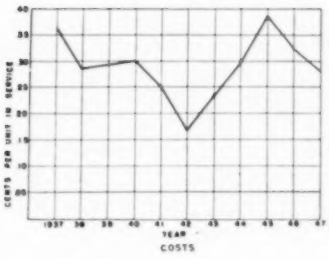
General Summary of Re-lamping and Luminaire Maintenance

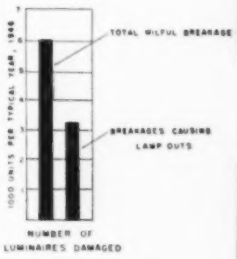
Washing and Lamp Maintenance.——In Fig. 6 is shown a diagram illustrating the relative numbers of unit washings, new lamps used, and lamp outages which come within a normal year of operation of 42,000 luminaires. There are approximately 78,000 washings, 79,000 new lamps used, and 14,000 lamp-outs replaced with salvaged lamps.

Willful Breakage.——Willful breakage is a problem which has to be combated continually.

Figure 9. Below. Luminaire willful breakage.

Figure 10. Right. High frequency current test of lamps.





Complete records are kept of this kind of damage, both as to location and extent. Such damage is negligible on traffic streets, but sometimes becomes excessive in residential areas, and not especially in the less favored ones either. Public acceptance of responsibility in this field, as in many other tax-supported services, could reduce the willful breakage problem to a very minor one.

Counter measures to reduce willful damage were instituted many years before the recent war, but had to be discontinued during the war years. A man is assigned for full-time duty for investigation of such cases, and to do appropriate educational work with school teachers, pupils, community associations, or in other places where good results can be obtained. He also cooperates with the Police Department, and in extreme cases arrests are made. This man is given a weekly report of damage cases for his guidance, and transmits a monthly report of damage by districts to school and police officials.

Luminaire Willful Breakage.—The annual amount of the cost of willful breakage is shown in Fig. 9. The increase during cessation of counter measures during the war is shown on the record.

In areas where breakage becomes extremely excessive, a wire guard is substituted for the glass globe, an effective but unsightly expedient. On upright standards, some globes are completely housed in a wide guard. This occurs near railroad grade separations or in some isolated locations.

In certain boulevard sections where a lantern type unit with flat panels is used, the glass will be replaced with transparent plastic plate. This has been effective up to 75 per cent.

Experiments are in progress on the use of pendant plastic globes. It is hoped that willful breakage will be reduced by the use of the plastic material. Some of the unsolved problems of plastic are as follows:

Manufacture in one piece instead of by cemented halves.
Distortion under possible heat maximum in service.
Practical minimum thickness to provide strength against stones or air rifle shots.
Lumen loss due to scratches during cleaning.

Favorable characteristics appear to be:

Satisfactory light transmission.
Less weight than glass.
Resistance to weather and discoloration or crazing said to be good.

Testing Procedure to Aid Maintenance

There are a number of procedures, testing methods, and equipment installations which may not appear closely related, but for our purpose are assembled here for consideration by those interested in any methods for efficient maintenance of street lighting. It is readily understandable that maintaining a normal 2000-hour replacement schedule with a standard 2000-hour lamp requires that all unnecessary interruptions or delays to expeditious operation of the schedules must be eliminated. Some of these procedures and tests are as follows:

(a) *Initial Lamp Testing—High Frequency Current Test.*—In order to reduce immediate or early air leak failures of new lamps, all are given an initial high frequency current test before they are given out for use by maintenance crews. The photograph of Fig. 10 shows how the lamps in a carton opened for marking described under section (c) below are tested quickly and accurately by the use of a simple and safe generator of high frequency current which can be held in one hand and touched in turn to the lamp terminals. Lamps with defective gas content are readily detected by an experienced tester who will note variations from normal in the typical striated purple glow rising from the filament. During the past year these rejects amounted to approximately 45 per month from the regular maintenance supply of lamps. No special training is required. Any conscientious lamp worker will become proficient in the test after a few hours' practice.

(b) *Sample Operation Testing.*—Sample lamps up to one-half of one per cent of each shipment received are placed in a rack for forced operation at 10 per cent over current (22 amps for 20 amp lamps) and burned for 300 hours. This test equals a normal life of 2000 hours. Due to the requirements of our maintenance schedule, we must be quite severe in the matter of acceptance of lamp shipments.

Thus all accepted lamps have a reasonable assurance of 2000-hour operation life.

(c) *Lamp Markings to Enable Post Service Check.*—Each new lamp that leaves the Lamp Room carries a number corresponding to the schedule period number in which it will be put into service. This number is applied by pen and glass marking ink at the upper end of the lamp neck. After a few minutes the number cannot be rubbed off or blurred, although it can be scraped off by a razor blade.

On removal from service by normal schedule, or from failure, each lamp is given visual inspection. The cause of failure will be apparent to a trained inspector. From the period marking number, its operation life can be determined; and if any district shows an excessive number of burn-outs, suspicion of overcurrent in the circuit can be followed up with investigation, and corrections made.

Lamps showing no re-welds in the filament are saved for abnormal replacement use.

(d) *Circuit Apparatus Checking.*—Circuit

current ammeters in substations are calibrated against a standard once a year, and defective ones replaced or repaired. Meters in manually operated substations are watched, and those in automatic substations checked twice each night by patrolmen.

Station constant current transformers are checked once a month for free movement of the floating coil. Outdoor constant current transformers are checked as to regulation and mechanical condition once a year.

Great care is exercised to make certain that power service equipment for lighting circuits is maintained in proper condition so that lamps will not be subjected to overcurrent.

(e) *Cathode Ray Oscilloscope Testing.*—For many years the only ways in which the operating department would know about lamp-outs would be from night inspection or from reports by citizens, and the Police Department. Prompt attention to calls from citizens is needed for maintenance of good public relations, but such a method cannot be wholly relied upon. Any complete program of visual night patrolling is cumbersome, tedious, and increasingly expensive. The cost factor in particular has urged the finding of a less expensive, easier and more effective way for the Lamp Room to acquire knowledge of lamp failures.

It is commonly known that an open in the secondary of a series transformer, such as is used to serve the bulk of our street lights, causes a ripple in the sine wave of primary series circuit current. By the use of a high inductance air cored reactor, this ripple is made readily perceptible on the screen of a cathode ray oscilloscope connected into the regular current metering transformer secondary. Knowledge of this fact gave rise to a desire to use the phenomenon as a means of tracing lamp-outs on circuits from substations.

By the use of some simple accessories at the substation board, the operator can quickly apply a portable oscilloscope in turn to the circuits so fitted. He does this immediately after starting up time and transmits the information of outages to the patrolman on night duty.

Visual patrolling in the area covered by the tested circuits is limited to those circuits showing outages. Many circuits will show no outage night after night. Generally there will not be over two or three outages on a circuit. By the use of a simple luminaire location map for each circuit, the patrolman soon makes a complete visual inspection from strategically located street intersections. In this way the night patrolmen make a very efficient use of their time, and are able to complete the replacement of a larger share of the lamps instead of reporting them for the next day's crew.

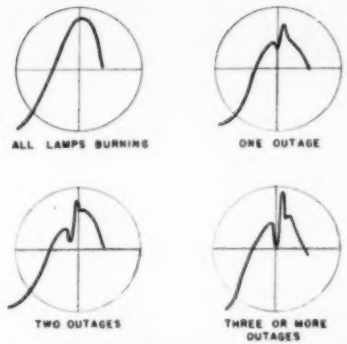
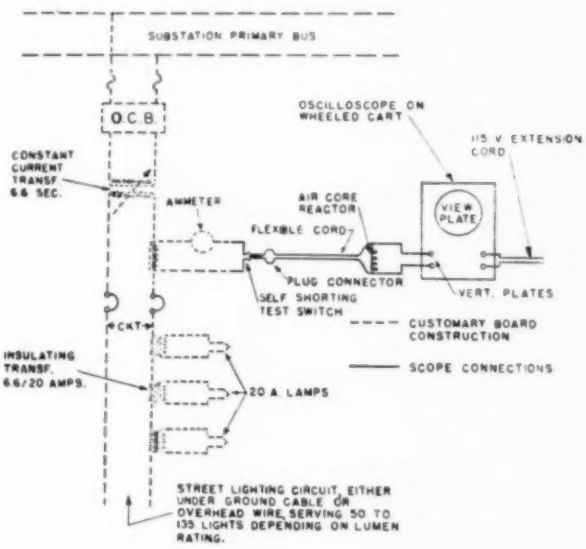


Figure 11. Oscilloscope curves from series lighting circuits, indicating lamp outages.

Oscilloscope Curves.—In Fig. 11 is shown a sequence of curves taken from an oscilloscope view plate. Curve (a) shows the clean sine wave of a circuit with all lights burning. Curve (b) with a small ripple at the peak indicates one lamp out. Curve (c) indicates the probability of two lights out.

Figure 12. Oscilloscope test connections.



Curve (d) with deeper valleys in the ripples indicates more than two lights out. The trouble man will check the circuit and replace all lamps until the scope indicates all burning.

Oscilloscope Test Connections.——In Fig. 12 is shown a diagram of station board connections which make this testing possible. In light lines are shown the regular necessary operating connections, and in heavy lines is indicated the special self-shorting test switch enabling quick connection for the portable scope on a wheeled cart.

Twenty-two of our substation circuits have been so equipped, and plans are now under way to extend the test system as far as practicable.

(f) *Visual Evaluation of Street Illumination.* In Detroit we use a special instrument called the Street Lighting Evaluator to determine whether or not a given installation provides the illumination value specified in accordance with accepted standards. The evaluator gives pavement brightness, object brightness and glare. A combination of these factors by the use of curves and calculations gives a figure which from experience indicates the value of the lighting system.

This method of street lighting evaluation is more effective and exact than the old photometer method, but it is still somewhat slow and cumbersome. It is hoped that photographic methods of evaluation will become available.

The Photometric Laboratory

One of the main cogs in the maintenance mechanism is the photometric laboratory. Here is provided a considerable amount of equipment suitable for the testing of lamps and luminaires as to light output and distribution. Also acceptance tests are made on new equipment, and periodic operation tests are made in the laboratory or devised for field test on coils, wire, cable, sockets, relays or any equipment used for street lighting. The operation tests may be on equipment which has been repaired, or they may be on equipment in service which is subject to failures, such as cable lines. Often an incipient failure is detected and repaired before it causes a service interruption. Some companies call such tests and repairs "preventive maintenance."

Gauges used by the maintenance men are designed here, and the men are periodically brought in to the laboratory and instructed as to what is expected of them in the matter of field adjustments, and are shown how to make these adjustments.

From time to time lighting fixtures are brought in from the field to the laboratory to determine the exact amounts of light depreciation which may have taken place where air conditions are bad.

Conclusion

The operation and maintenance methods described here, together with the constant testing and experimenting program, have produced many good results. We have maintained an average nightly outage of about .09 per cent, or one outage per 1100 lamps in service, and an overall efficiency of luminaire light output of 90 per cent.

The Public Lighting Commission appreciates the fact that a properly maintained street light is its best advertisement. All the work of the maintenance division is directed toward that objective. The result is that Detroiters are accustomed to seeing the luminaires burning with a clean and attractive appearance. In fact our citizens have become so street light conscious and so interested in good illumination that a large portion of the outages is reported quite promptly. Special effort is made to take care of these complaints promptly in order to encourage this excellent cooperation.

Unsolved problems still remain, such as a satisfactory winter dry cleaning method, and an acceptable substitute for wire lamp guards. Also some procedures, such as the oscilloscope testing, are subject to further improvement.

Our experience shows that a well designed street lighting system, maintained to a high standard of light output is found to be economical, and that it increases night traffic safety and adds much to the beauty of the street.

Keeping the Street Lights Bright creates good public relations.

DISCUSSION

R. M. Hoot:* I would like to ask Mr. Schrenk what his experience has been with Alzak reflectors in totally enclosed units. Assuming that the optical assembly is kept tight, what life do you expect to obtain from such a reflector, and if not kept tight, what life do you expect?

G. E. Kobten:** This paper presents many new ideas, and two of the most interesting are the high frequency current test for locating air leak failures in new lamps and the cathode ray oscilloscope test for locating burned out lamps in series circuits. It would be interesting to learn if any other street lighting operating people are using these testing methods or other similar methods to reduce outages of lamps.

The reweld depreciation chart shown in Fig. 5 is very interesting, as it has been difficult to obtain a chart which showed the approximate depreciation of lumen output due to the rewelding of a series lamp. This should be interesting to some operating people who leave lamps in service as long as there is any light. It is often reported that 20 ampere series lamps with as many as six or seven welds in them are removed from service. In these cases, street lighting customers would probably be getting less than half the light they would get from a well maintained luminaire. A better maintenance program including group replacement of lamps should improve these conditions.

*Philadelphia Electric Company, Philadelphia, Pa.
**Consumers Power Company, Jackson, Mich.

Natural and Artificial Sunlight; Their Application in Testing Materials

By A. H. TAYLOR

The properties and characteristics of many materials can be adversely affected by exposure to sunlight under various weather conditions. Typical examples are the fading, blistering and chalking of paints; bleaching, fading and loss of strength of textiles; reduction of flexibility of rubber, leather, etc. The author explains several complex factors which independently or dependently, may contribute to these changes.

TWO FACTORS are particularly important in considering the changes in properties and characteristics of materials exposed to sunlight. These are: intensity and spectral distribution of the radiant energy in sunlight and skylight, as well as duration of exposure. The constantly changing intensity in a 24-hour cycle may also be important. Humidity and temperature, neither of which is constant, may be further contributing factors.

Radiant energy in different spectral regions (ultraviolet, visible and infrared) in sunlight

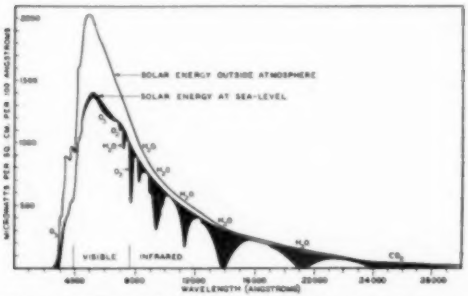


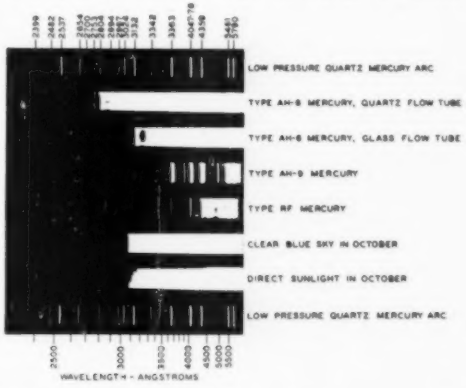
Figure 1. Spectral distribution of radiant energy from the sun which reaches the earth's surface on a very clear day. Effects of atmospheric absorption in various spectral regions are indicated approximately by the black areas.

varies greatly in its photochemical effect. Ultraviolet energy, from λ3000 to λ4000, is photochemically very active on many materials, and may promote bleaching, fading and disintegration. For some dyed materials the spectral region shorter than λ3500 may be of relatively greater importance than that from λ3500 to λ4000. However, Dr. Matthew Luckiesh and the author have found[1] that fading of dyed textiles by sunlight may be produced by all wavelengths shorter than approximately λ6000, the orange-red region. Incidentally, this shows that it is impractical to stop fading of colored goods in a show-window by use of selective filters. Any filter which would completely protect from sunlight would be so strongly colored that the true color of the goods would not be distinguishable. However, filtering out all energy shorter than λ 4000 should *reduce* the fading.

Colored materials such as plastics or textiles differ among themselves in the relative damage produced by energy in different spectral regions. Consequently, it is difficult or impossible to assign a definite equivalent exposure-ratio of artificial to natural sunlight, excepting for a very limited application. The validity of such a ratio increases if the two are nearly alike in intensity and spectral distribution in all spectral regions shorter than λ6000. For the red and infrared regions the effects are principally those due to increased temperature, produced by absorption of the radiant energy.

There would be many obvious advantages if sunlight could be "brought indoors" for test purposes, as it would then be possible to control independently some of the other complex factors such as tem-

Figure 2. Spectrograms of radiant energy from various mercury lamps and from sunlight and skylight in October.


LOW PRESSURE QUARTZ MERCURY ARC
TYPE AH-6 MERCURY, QUARTZ FLOW TUBE
TYPE AH-6 MERCURY, GLASS FLOW TUBE
TYPE AH-9 MERCURY
TYPE RF MERCURY
CLEAR BLUE SKY IN OCTOBER
DIRECT SUNLIGHT IN OCTOBER
LOW PRESSURE QUARTZ MERCURY ARC
WAVELENGTH - ANGSTROMS

MR. TAYLOR is a physicist in the Lighting Research Laboratory of the General Electric Company, Nela Park, Cleveland, Ohio.

perature and humidity. Natural sunlight and mixed sunlight and skylight are variable in intensity and spectral distribution from day to day and at various hours of any day. However, it is probable that if one could duplicate midsummer noon sunlight and skylight, as found in the latitude of Washington or Cleveland, it would be satisfactory for most test purposes.

An overall picture of the spectral distribution of sunlight is presented in Fig. 1.[2] The author and G. P. Kerr have made many measurements of the spectral distribution of energy in daylight.[3] Separate series of measurements were made in the region λ3000 to λ4000 and the region λ4000 to λ7000. Measurements throughout the whole range from λ3000 to λ7000 were not made on any single day.

In order to determine the spectral distribution of total solar energy throughout its entire spectral range it has been necessary to combine data from various publications as well as our own observations. The final values, tabulated in Table I, represent the best estimates obtainable from our own observations[3] and the various sets of published data,[4, 5, 6] calculated for energy from the sun and a clear sky on a horizontal plane at midday in midsummer, latitude of Cleveland or Washington. At the maximum solar altitude of 73° the total energy on a horizontal plane is approximately 84 watts per sq. ft.[7]

No single light-source produces an energy distribution which even approximates that of sunlight throughout the whole range of λ3000 to λ26000. The so-called sunlamps were developed to approximate, in therapeutic benefits and the tanning of human skin, the results obtained with natural sunlight. From these sources the ultraviolet energy of wavelengths near the short-wavelength limit of sunlight is concentrated mainly in three lines of the mercury spectrum. While these lamps have been used in certain tests of materials such as the fastness of dyes and paints, their usefulness in this field is definitely limited.

Table I. — Approximate spectral energy distribution of sunlight (8400 footcandles) and skylight (1600 footcandles) on a horizontal plane at midday in midsummer, latitude of Cleveland, Ohio. Also, artificial sunlight composed of energy from an AH-6 water-cooled mercury lamp (6600 footcandles) and a 500-watt tungsten-filament lamp (1000 footcandles).

	Watts per Square Foot			
Spectral Range	Sunlight 8400 Ft-c Skylight 1600 Ft-c	AH-6 Water-Cooled Mercury Lamp 6600 Ft-c	500-watt Tungsten 1000 Ft-c	AH-6 Plus 500-watt Tungsten
λ3000 - 3500	2.4	2.2	0.0	2.2
3500 - 4000	4.8	6.2	0.1	6.3
4000 - 5000	13.4	12.6	0.6	13.2
5000 - 6000	14.2	10.3	1.4	11.7
6000 - 7000	12.3	2.2	2.3	4.5
7000 - 10000	18.2	4.5	9.7	14.2
10000 - 14000	11.7	3.6	12.6	16.2
14000 - 26000	7.0	....	15.7	15.7
	84.0			84.0

Several years ago the present author found, from known energy distributions, that the spectral distribution of natural sunlight and skylight could be approximated by combining the radiant energy from a 1000-watt water-cooled Type AH-6 mercury lamp with that from the regular 500-watt tungsten-filament lamp. The AH-6 lamp is a high-pressure lamp radiating a continuous spectrum throughout the ultraviolet and visible, λ3000 to λ7000, as shown in the spectrogram of Fig. 2.

Table I shows the energy values for a combination of one each of these two sources. Comparing the values in the last column, for the combination, with those for natural daylight in the second column, it is seen that the approximation is fairly satisfactory for all regions below λ6000, the light red, and that the greatest deficiency is in the region λ6000 to λ7000.

As has already been stated, fading of dyed textiles is produced principally by energy of wavelengths shorter than λ6000. Some changes in materials such as the loss of flexibility are probably due to elevated temperatures brought about by absorption of radiant energy. Such changes are not likely to be greatly influenced by differences in spectral distribution of natural and artificial daylight in the infrared, such as are shown in Table I. Consequently, from the standpoint of energy distribution the combination of equal numbers of 1000-watt AH-6 water-cooled mercury lamps and 500-watt tungsten-filament lamps would appear to be a fairly satisfactory approximation to natural daylight.

One very practical aspect of the application of this combination of lamps is the necessity for reflecting equipment which will provide a fairly uniform illumination, well mixed, over the desired exposure area. Aluminum reflectors should be used to insure good reflectance for the region λ3000 to λ4000. Selection and installation of the proper reflectors are problems well within the experience of illuminating engineers.

In an installation involving a number of lamps of each type a different method of installation might be used. By use of a ceiling of diffuse Alzak and side-walls of the same material down to the level of the exposure plane, individual reflectors would not be necessary. This would probably increase the uniformity of the energy mixture and

reduce the effect of one lamp burning out during the test-period.

The initial output ratings are 65,000 and 10,000 lumens for the AH-6 mercury lamp and the 500-watt tungsten lamp, respectively. Assuming a utilization factor of 60 per cent for each lamp and an average depreciation of approximately 15 per cent, there would be required one lamp of each type for each 5 square feet of test area.

The AH-6 lamp has a rated life of 75 hours, based on tests employing 25-minute burning periods. Under conditions of continuous burning, the actual life may be two or three times greater.

The high costs of installation and power for this combination source limits its application to those cases where definite results are likely to be obtained in 100 hours or less or where the need for quick results outweighs cost of operation. Obviously, it would not be feasible to use it for tests of roofing materials, for example, whereas tests of plastics or textiles might readily justify its use.

If a particular spectral region is maximally effective in certain reactions, it may be possible to use an abridged test-method. One of the technical societies has standardized methods of testing the color-fastness of plastics using a Type S-1 sunlamp. Since there are unavoidable variations in initial output of such lamps and a constantly decreasing output of ultraviolet energy during life, there will be corresponding variations in the results obtained. The RS sunlamp is similar to the S-1, but individual lamps vary in the same way.

For many years there has been available a "Fadeometer," employing a high intensity carbon arc. The carbons radiate a high intensity of energy in the spectral region λ3000 to λ5000. It is used for accelerated fading tests.

Germicidal lamps are very efficient producers of energy at λ2537. This energy has been found to be very effective in some photochemical processes such as fading of textiles. They can be used for some qualitative tests of color-fastness. In a test with colored textiles the author found[8] that a single bare 30-watt germicidal lamp at a distance of 26 inches produced as much fading, in one-tenth the time, as was caused by 200 to 300 footcandles from daylight fluorescent lamps. Since the fading with the germicidal lamp was produced by energy of a wavelength (λ2537) shorter than any present in sunlight, results may not be directly comparable. However, lack of fading or slow fading under the germicidal lamp will probably correlate well with very slow fading in sunlight.

References

1. Luckiesh, Matthew, and Taylor, A. H.: "Factors Affecting the Fading of Dyed Textiles by Radiant Energy," *American Dyestuff Reporter*, p. 543, Oct. 14, 1940; ILLUMINATING ENGINEERING, Vol. XXXV, No. 2, p. 169 (February, 1940).

2. Luckiesh, Matthew: *Applications of Germicidal, Erythemal and Infrared Energy*, D. Van Nostrand Company, New York City, 1946.

3. Taylor, A. H., and Kerr, G. P.: "The Diarribution of Energy in the Visible Spectrum of Daylight," *Journal of the Optical Society of America*, Vol. 31, p. 3, 1941.

4. Smithsonian Miscellaneous Coll., Vol. 74, No. 7, p. 15.

5. Kimball, H. H.: "The Distribution of Energy in the Visible Spectrum of Sunlight, Skylight and Total Daylight," *Proceedings of the International Congress on Illumination*, p. 501, 1928.

6. Gage, H. P.: "Spectral Distribution of Solar Radiant Energy," *Transactions of the Illuminating Engineering Society*, Vol. XXXIV, No. 3, p. 316 (March, 1939).

7. Smithsonian Physical Tables, 6th Edition, p. 181.

8. Taylor, A. H.: "Fading of Colored Textiles," ILLUMINATING ENGINEERING, Vol. XLI, No. 1, p. 35 (January, 1946).

MODERN LIGHTING FOR A MODERN LIVING ROOM—General lighting is furnished by a continuous cove concealing an unbroken line of fluorescent lamps. The sectional divan is backed by a fluorescent lighted ledge giving accent to the border of Chinese prints above.—Photo courtesy Westinghouse Electric Corporation.

Methods of Illuminating

By THOMAS SMITH KELLY

IT HAS often been said that illuminating engineering is more of an art than a science. While the basic principles of light control follow physical laws, there are many intangible factors involved in designing an effect which will appeal to our sense of esthetics. This discussion approaches the subject of lighting from the standpoint of the artisan who is more concerned with an artistic result than with engineered efficiency.

Through the sense of sight, we are able to evaluate objects of art, architecture, interior design, etc., in terms of emotional appreciation. If some object is illuminated in a way that appeals to our sense of beauty, it makes us conscious of our finer emotions—creating a feeling of joy, love, happiness, peace, etc. We may then say that the lighting has produced an esthetic result or it may be called esthetic ilumination.

On the other hand, if the lighting is harsh, glaring, uneven, or spotty, we may feel uncomfortable, ill at ease and bothered. When objects are illuminated in this fashion, they may look flat, dull, indistinct, and will not hold the attention or interest as they lack an esthetic quality. To illustrate my meaning, let us look at the pictures shown in Figs. 1 to 4.

I propose to discuss this apporach to illumination and point out how to achieve this sense of beauty, this pleasing, artistic emotional quality.

Figure 1. Top left. Too much light makes this photograph of a statue uninteresting and flat. Taken with floodlights, it lacks shade and contrast.

Figure 2. Center. For this silhouette, the statue was placed in front of and close to a screen which was evenly lighted from behind. For sharp outlines the silhouette edges were placed equidistant from the screen.

Figure 3. Far left. Insufficient light makes the contrasts too sharp and the shades arbitrary and ugly. It was taken in a dark room with only one light—a spot—placed above and to the left of the statue.

Figure 4. Left. Correctly lighted, the photograph assumes a plastic, three-dimensional effect. In addition to the light used in Figure 3, a second light was placed in front, slightly to the right of the statue.

Art Objects and Pictures

The emotional appreciation of all visual forms of art depends to a great extent on the illumination that permits them to be seen. Mr. Kelly explores this field with special reference to artificial illumination, emphasizing the esthetic rather than the engineering approach.

Anticipating one frequent question, I will admit that it is very difficult to prove that any lighting effect is beautiful and has a pleasing quality for everyone who sees it. This fact is true in all expressions of art. One person may be overcome when looking at a primitive painting, while another experiences a similar emotion when he sees a Salvador Dali. The same thing applies to music, sculpture, architecture and literature. All one can do, then, is to try to develop a technique which pleases oneself and after a while, he will have a following of people who think and feel the same way that he does.

Where does one study this phase of illumination? The answer lies between the lines in recognized books on photography, painting and almost any form of art, and by studying paintings of the great masters. The theatre is also a source of inspiration and of course, so is natural scenery. Here we can learn more about esthetic lighting than anywhere else, if we take time to analyze what we see and make notes. The light and shadows in a landscape are always changing. Having observed effects from these sources of information, we will want to make a list of our findings so that we can apply them when we begin to develop our own lighting technique. There are many helpful facts to remember, which will be discussed as we proceed. For instance, we will discuss the illumination of fine paintings, murals and other wall treatment of a two-dimensional nature. We will discuss ways to light bookcases, curio cabinets, statues, dining room tables; all of which have three dimensions. Then we will take up staircases, hallways and so on, tying in accent or special feature lighting with the general illumination of each area.

Here are ten practical points to remember:

1. Specular surfaces cause glare. Plan the angle of incidence so that reflections will not spoil the effect you are trying to achieve.

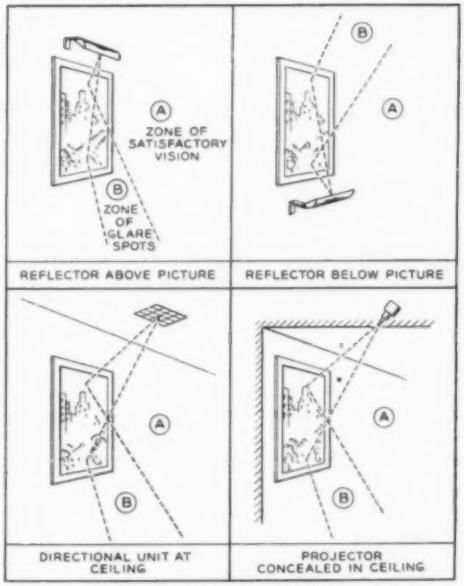


Figure 5. Picture lighting.

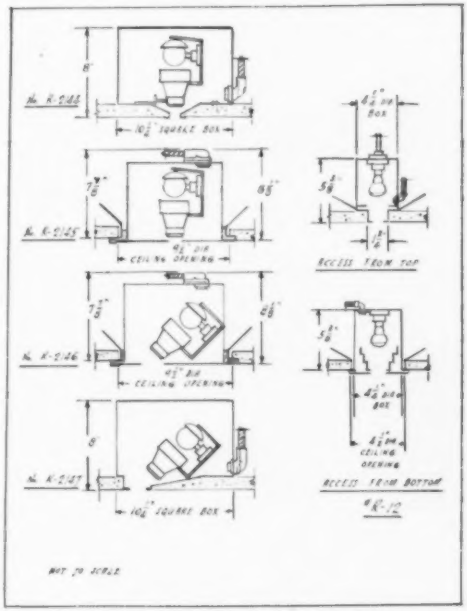


Figure 6. Details of pin-hole spotlight.

A paper presented at the National Technical Conference of the Illuminating Engineering Society, Boston, Mass., September 20-24, 1948. MR. KELLY is a Lighting Consultant, New York, N. Y.

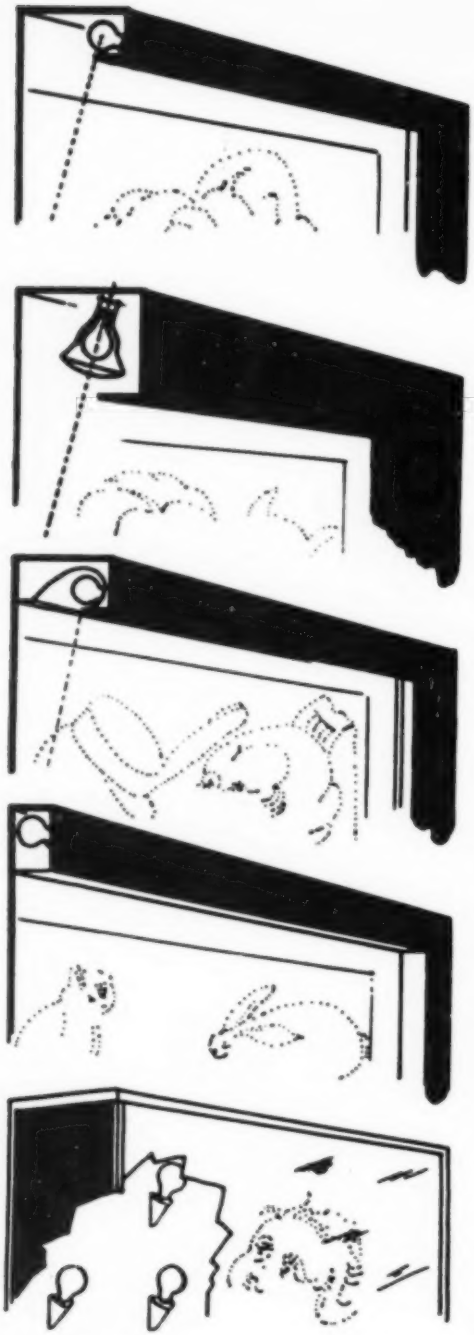


Figure 7. Types of wall and mural lighting.

2. Think of the effect you want first, then select the lighting equipment and angle which will give you that effect.

3. Light coming from an angle of 45 degrees from the vertical produces natural and interesting shadows of three-dimensional objects.

4. When lighting for three dimensions, two light sources are better than one.

5. The first source should be a strong and definite one. The second should be of lesser intensity and indefinite (diffused).

6. The light from each source should fall from a different angle.

7. Whenever possible, install the lighting equipment first; then match your colors, carpets, wallpaper, painting, etc. in that light.

8. The psychological approach, the likes and dislikes of the client must be carefully considered in determining the effect.

9. Light coming from directly overhead is very unflattering to anyone directly under it.

10. Illuminate an object without revealing the source of the light and you will be on the way to a real achievement of lighting application.

Point No. 10 seems to revolve around two factors; (one) the distribution of light and (two) the sight line. Light distribution should be governed in many cases by the sight line. Take a light source, a simple incandescent lamp for example, and suspend it a foot below the ceiling. In order to avoid the glare from the lamp itself to an observer standing at the farthest possible distance, we will place beneath the lamp a hollow object such as an opaque bowl and keep pushing it toward the lamp until the lamp itself is cut off from the observer. The resulting distribution of light then, is really what is left after shielding the bulb from the line of vision. Of course, these points are generalities and there are many occasions where one cannot strictly adhere to them. I may as well mention colored light at this point. This is a study in itself, and should be used with great restraint. Most homes are colorful enough in themselves. However, if point seven is followed carefully, pastel shades of orchid, blue, straw, pink and amber may be used at times.

The majority of home owners favor warm tones indoors and daylight blue (synthetic moonlight) out-of-doors. Soft-white fluorescent or incandescent lamps colored an orchid-pink are excellent for viewing complexions and make food, such as roast beef, tomato catsup, shrimp, etc., look very appetizing. Straw or amber gives a good imitation sunlight while pale ivory can be recommended for a soft general lighting effect in a living room. If one goes in for parties or amateur theatricals, a mixture of blue, red, amber and green on separate dimmers will give almost any color effect desired.

Paintings

I have been giving you generalities and we are now ready to take up specific examples. We will begin by studying the illumination of paintings, murals and other two-dimensional surfaces.

Looking at our list of things to remember, we will note that No. 1 and No. 2 refer to specular surfaces. We almost always find specular surfaces on oil paintings, as they are varnished for protection. Here the light must strike the painting a glancing angle from the top, the sides or from underneath. We must never try to light a surface of this kind directly head-on as we would not see anything but a diffused image of the light source.

Let us consider some of the equipment used for picture lighting. First, there is the conventional method of placing a small fixture above or below the frame. This type of fixture usually consists of one or more tubular lamps set in one plane parallel to the top and bottom of the frame. The lamps are shielded from the observer allowing light to fall over the surface of the picture. Usually the inside of the shield contains a reflector. The T-10 showcase reflector lamp, when properly adjusted, does an excellent job without the use of auxiliary reflectors. The fixture may be held in place by one or more brackets. These may be attached to the back of the picture frame or to the wall.

The exact position of the unit, as related to the picture, is very important. The unit should be set high enough so that the upper portion of the frame is not obscured. The exact distance depends upon the mounting height of the picture on the wall and the height of the picture itself. If the unit is too low, it will not only obscure the frame, but will cause glare at the top of the picture, especially if the picture is a varnished oil painting.

The unit must also project out in front of the picture, far enough to allow the light to illuminate the entire surface. If the unit is set in too close to the top of the picture, little or no light will reach the bottom. This position ratio is about 3 to 1. That is, if the center of the light bulb is placed three inches out from the painting, it will illuminate about nine inches down on the surface of the picture. The T-10 showcase reflector lamp or a fixture with a lens will do better than this, perhaps about 5 or 6 to 1.

Where several paintings are placed together, a continuous luminaire can be installed upon the ceiling or several individual units can be placed on the ceiling and concealed by means of a hollow ornamental cornice. The equipment may also be built in above the finished ceiling, the light passing through translucent glass, plastic, or louvers, or just through an opening in the ceiling.

Sometimes it is better to light a picture from below. If the picture is hung over a high table or other piece of furniture or over a mantel, the unit may be concealed in the top of the furniture or placed in an attractive box or bowl. Very often a table or floor lamp can be placed on one side or under the painting with excellent results.

The most subtle method of lighting an oil painting is by means of an optical projector. This consists of a high intensity incandescent light source, a reflector, a double-convex lens or condenser with adjustable baffles or other means of holding a stencil in front of the condenser. In front of the baffles, an objective lens is generally mounted in a tube. The baffles are adjusted to cut off all spill light, leaving illuminated only the canvas upon which the picture is painted. The projector should be concealed behind a wall or above the ceiling, the only visible part being a small hole through which the light passes. If the placing of the unit is carefully planned, one sees only the illuminated painting.

Figure 8. Below. Methods of lighting statues in niches.

Figure 9. Right. Lighted statue in niche. As sculpture in niches serve as interest points, they should have five to ten times the illumination of adjacent surfaces.

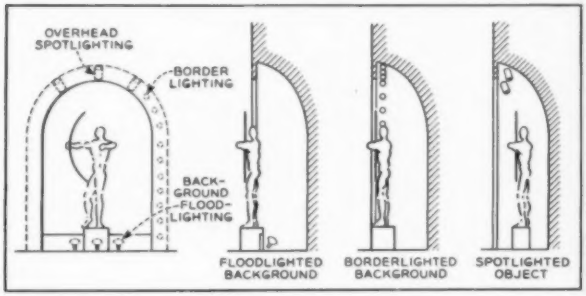


Figure 10. Illuminated stairway.

In selecting a location for the projector, one must use great skill and forethought to avoid glare from the picture and the direct beam of light from the small opening in the ceiling. In general the light should strike the canvas at an angle somewhere from 20 to 30 degrees. If the unit is installed too near the vertical plane of the painting, the frame may cause shadows on the canvas. The best position is usually just far enough out in front of the painting to miss the frame. When the unit is placed in the ceiling above the painting, you need not worry so much about the angle of reflection or bad angle of view.

When illumination is from one side or the other, the seating arrangement of the room must be considered in order to give the best possible view from all points of the room. This system should not be used alone with no other lighting in the room as it produces a weird effect, making the paintings look like stained glass windows or illuminated transparencies. There should always be harmony and balance for esthetic results. Another factor relating to picture lighting is to be sure that the picture is firmly secured to the wall. It should be fastened at two places and should rest flat against the wall and not hang out at the top. Wherever possible the picture should be framed without glass to avoid reflections and unwanted images.

In summing up the various methods, my advice is to leave the optical projector method to the experts. The other methods are much easier to work out and many authorities feel that optical projector lighting, unless carefully executed, is apt to be too dramatic for many interiors. However, I believe that this method used in conjunction with a well balanced general illumination, enables one to see a painting at its best.

Murals

Decorated walls, like paintings, can be illuminated by continuous or unit equipment. The technique is much the same. The equipment may be concealed within the ceilings or walls, or placed upon the surface and covered by a suitable molding or cornice. Annoying reflections and sharp contrasts should be avoided when the light source is recessed within or above a ceiling. Unless specially designed equipment is used, the top of the vertical surface will not be illuminated. Various tricks can be employed to remedy this situation, however, such as adding reflecting surfaces to the interior of the equipment so that spill light will be directed to the otherwise shadowy area.

Placing the light source below eye level inherently avoids reflections, but this method can only be used where it is possible to conceal the equipment so it will not be disturbing or within easy reach of the public. In some cases, equipment may be built into ledges, wall cases, or table tops and behind banquettes. With an average 8 to 9 foot ceiling, if the equipment is placed about 18 inches out from the wall, good results will be obtained.

Either incandescent, fluorescent or cold cathode light sources can be employed. However, if good results are to be obtained, either an accurately made polished aluminum or mirrored reflector must be used to send the light over the surface, or a suitable lens designed for the purpose may be used instead of the reflector. Without reflector or lens, the equipment usually has to be placed much farther out from the wall in order that the wall be evenly illuminated.

Transparencies may be lighted by lamps uniformly spaced behind them. Lamp spacing should not exceed 1½ times the distance from lamp to glass. They may be lighted also by a wedge-type or paracyl reflector with the light source at the base of the wedge or centered in the circular part of the paracyl.

Portable posters may be lighted by carefully masked spotlights so located that people can neither face the beam nor walk through it.

Sculpture

For three dimensional objects, we will refer to points three, four, five and six. Of course, the

specular surface rule still applies but as we have a third dimension we must consider distance and perspective. In order to produce a feeling of distance, more than one light source must be used. The second source can be reflected light, general illumination, or a specially installed source. The optical projector, already described, may be successfully employed.

Sculpture in niches serve as interest points and should have five to ten times the illumination of adjacent surfaces. Silhouettes are desired when only the contour of the figure is of interest and the detail unimportant; in others the background may best be employed for color and atmosphere with the object sharply spotlighted in white light. In other instances, strong directional light in various colors will create striking color shadows.

Other uses for the pinhole or optical projector are stairway and hall lighting, dining tables and similar applications.

Stairway, Hall and Dining Room

For stairway and hall the unit (Fig. 10) is concealed above the plaster ceiling allowing the light to spread over the steps bringing out the architectural detail without annoying fixtures or blinding glare.

In illuminating dining table decorations, a unit may be concealed above the dining room table. Access can be from the floor above. A small trap-door is provided through which the unit can be reached. Where the floor above is not accessible, a steel plate can be provided to fit flush on the ceiling, the light passing through a small one-inch hole. To reach the unit for relamping, the plate can be removed.

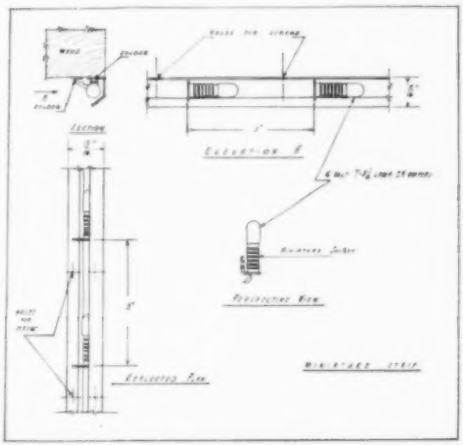


Figure 11. Shelf and cabinet lighting. Diagram of installation, above, right

Illumination of Curio Cabinets

The contents of curio cabinets may be illuminated in several ways. Fig. 11 shows a cabinet lighted by means of a low voltage incandescent lamp strip using T-3¼ panel lamps. The strip is attached to the underside of a wooden or glass shelf thus illuminating the contents of the shelf below. In some cases where the shelf is above eye level, the strip may be placed on the upper surface of the shelf, lighting the underside of the objects upon the shelf.

As the strip is less than one inch in thickness, (see diagram for detail) it is hardly noticed, and the effect produced is soft and mysterious.

This miniature strip has many other uses where low intensity illumination is desired. It can be used for the illumination of bookcases also. Here the strip is installed in the same manner as in curio cabinets. The books are then pushed one inch or so away from the strip. The color and lettering of each book cover is bathed in a soft glow of light. When more light is needed, a T-5 fluorescent lamp can be used. However, fluorescent strips are usually somewhat larger than incandescent units even when the fluorescent starters and ballasts are concealed in a remote location.

Translucent objects made of amber, jade, or thin porcelain sometimes look better when placed upon a luminous shelf of opal glass. Sometimes clear glass shelves with light behind them are masked except directly beneath the objects. This allows light to come up through the shelf making the objects themselves luminous. This is called "edge lighting."

Controlled lighting can be placed in these classifications:

1. Downlighting
2. Up-lighting
3. Projection (illustration of R-12 pin-hole)

Up and downlighting can be accomplished by three types of equipment: (a) cans or compact units, (b) strips, and (c) luminous elements, or combinations of several of these.

While it covers only a small part of a vast subject, it is hoped that this paper will stimulate some of those engaged in architecture, decorating, and lighting to apply the principles to creating esthetic illumination in the homes of their clients.

DISCUSSION

BERLON C. COOPER:* I think Mr. Kelly has given a very comprehensive coverage of ways to illuminate art objects and paintings. As he pointed out early in his paper, any lighting result provided on some particular painting or object of art will appeal to some people and not to others. This is a field in which the lighting engineer no doubt runs into a wider range of personal likes and dislikes of the lighting effects provided than in any other field.

I agree with Mr. Kelly that paintings and art objects seem to show up to best advantage in rooms which are provided with some general low level shielded lighting, and with supplementary direct lighting on the painting or art object. However, I have seen a few art rooms which were lighted by totally indirect lighting only, and seemed to provide very satisfactory lighting for both paintings and art objects. These installations have used both suspended luminaires and cove lighting. These installations were made osme twenty years ago, and used incandescent light sources. I wonder if Mr. Kelly has any specific reason for not including indirect lighting as one method for lighting either paintings or art objects.

STANLEY MCCANDLESS:* Mr. Kelly writes with the authority of experience in lighting pictures, tapestries, sculpture, etc., in many houses. He even practices what he preaches in his own house, so that he has the further judgment of having "lived with it."

If there is any criticism, it is perhaps that he has tried to cover too much ground. At the end he touches on downlighting, uplighting, and projection, which might better have been left out.

The simple direct statements and suggestions in the balance of the paper give methods and approach, but the ingredient of taste and skill required in adjustment is only implied.

The important contribution of this paper is the emphasis on the need for lighting works of art and the importance of distribution before color and intensity.

Any work of art in the visual field is conceived to be seen. The visual aspect of almost any building, picture, or sculpture may benefit by well studied artificial lighting. Mr. Kelly has unfolded a field of lighting that needs broader application.

K. A. STALEY:** Mr. Kelly has presented refreshing material in the field of illuminating engineering in which he is most expert. His paper will be valuable reference material for many years to come. His suggestion to take time to analyze what we see and make notes is a most engaging and subtle proposal for our guidance. The proposal does not state it directly but we can assume that the reader will follow through with experiments of his own in his own home, as Mr. Kelly has in his.

If the Society members would carry out this one idea, we would have thousands of fine examples for our clients to see and the effect would be far-reaching. Good lighting, like charity, should begin at home.

Mr. Kelly's paper reminds me of a book by Rudolph Flesch, published by Harper & Brothers. Its title is "The Art of Plain Talk." In the book, the author makes a plea for simple, understandable language. If you read the book, you will no doubt come to the conclusion that our professional jargon is stuffed with "gobbledy-gookish" words and phrases. Mr. Kelly has avoided them. As a result, his paper is easy to read and to understand. It is a mark of quality which should be more widely sought by those who write about light.

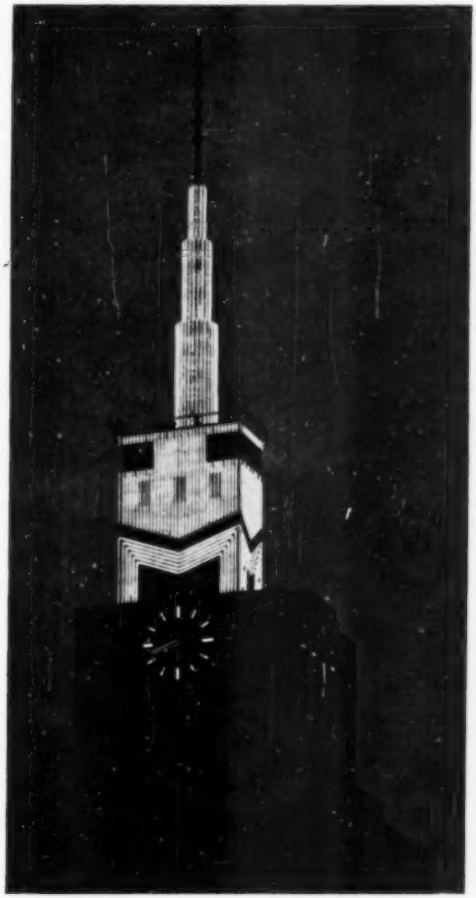
*McGraw-Hill Publishing Company, New York, N. Y.

*Century Lighting Company, New York, N. Y.
**Lamp Dept., General Electric Company, Nela Park, Cleveland, O.

A.I.A. File No. 31 f 17

Lighting of a Tower

LIGHTING OBJECTIVE: To illuminate a tower, providing a striking landmark on the night-time skyline.



Installation on the tower of the Mercantile Bank Building, Dallas, Texas.

General Information: The overall height from the sidewalk to the beacon surmounting the antenna tower of the FM station KERA, *Dallas News*, atop this building is 545 feet. The 70-foot tower is constructed in three cylindrical sections of 21 tons of steel. The face of the clock shown in the photograph is 24 feet in diameter.

Installation: The tower is illuminated with 10,450 feet of cold cathode tubing. Of this tubing, 7,950 feet are daylight white 18 mm, 60 ma with an output of 146 lumens per foot and a brightness of approximately 900 footlamberts; 2500 feet are of rose 18 mm, 30 ma tubing with an output of 60 lumens per foot and a brightness of approximately 400 footlamberts. The power required for operation is 167 kva or 83 kw. Sixty-four circuits with special flashers are utilized.

The luminous area extends 115 feet high, including the four upper stories of the building and the 70-foot tower. (Windows of next-to-top story show through the tubing.) The lighting effect gives the illusion that the upper and lower sections of the tower are revolving counter-clockwise and the center section clockwise.

Equipment used was General Luminescent tubing and Sola transformers.
The luminous area was designed and installed by Outdoor Electric Advertising, Inc., of Dallas, and the structural tower was designed by Arthur Kendrick, Consulting Engineer.

Lighting data submitted by W. E. Folsom, Dallas Power & Light Company, Dallas, Texas, as an illustration of novel design and to aid in the design of similar installations.

Distributed by the Committee on Publications of the Illuminating Engineering Society, 51 Madison Ave., New York 10, N. Y.

Series XIV 4-49

A.I.A. File No. 31 f 17

Planned Restaurant Lighting

By MAURICE W. ROSS

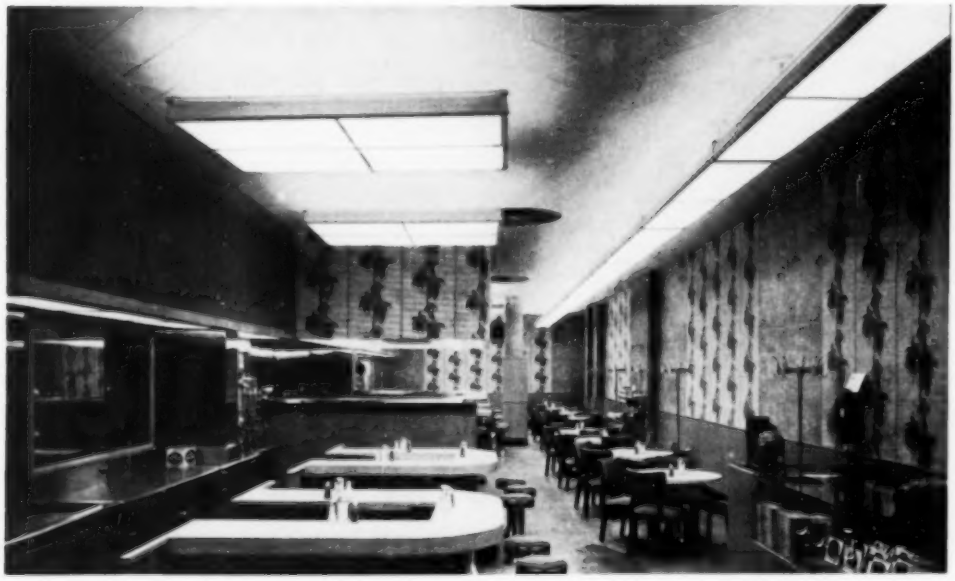
ALL of the functions of store lighting come into play in the lighting of a restaurant. The designer must keep in mind the atmosphere of the interior, attraction to the establishment and to displays, and to some extent the appraisal of the food, at least from the standpoint of its appearance. These three functions of lighting are of importance in varying degrees depending on the type of restaurant being considered. To the restaurant which depends on passing traffic for its patronage the element of attraction is of most importance. To the one which is more concerned with providing pleasing surroundings to which the guests will want to return again and again, the elements of atmosphere and appraisal will be uppermost in mind.

Restaurants are often considered as divided into three general types of which there may be any number of combinations. First there is the "intimate" type such as in taverns and night clubs where the level of illumination is kept low, perhaps in the order of 5 footcandles. This illumination is usually provided in such a way that it is predominantly horizontal so menus can be read and food appraised but so there will be no detraction from the intimate effect desired. Another type is the "leisure" type in which moderate values of illumination of from 10 to 20 footcandles are found. The hotel and club dining room falls into this class. The third type is the "traffic" type, often located on the street level, such as lunchrooms, cafeterias and coffee shops. In this third type the lighting level requirements are considerably higher than for the other types.

The "Have-A-Snack" restaurant recently opened at 127 West Monroe Street, Chicago, Illinois is a restaurant of the third type, in which an illumination level of 50 footcandles was provided. From previous experience in this type of business the owners felt that this magnitude of illumination was completely desirable, despite the fact that such lighting levels are not commonly found for the general illumination of similar places in the vicinity.

Mr. Ross of Chicago, Illinois, is chairman of the I.E.S. Committee on Store Lighting.

Figure 1. Arrangement of lighting elements and interior finishes in this restaurant was well planned, to give a comfortable and pleasing atmosphere.



In conjunction with the higher levels of illumination, the owners and designers felt that light colored counter tops, cabinet trim and floor combined, would not only provide a feeling of cleanliness and meticulous care in the preparation and serving of food but would also provide a high utilization of the lighting and attract the attention of persons passing the front of the establishment. The light surroundings which were closely related in reflection values makes the interior very comfortable. Such high level illumination could be quite uncomfortable in an interior where less thought was given to finishes than was done by the designers in this instance. It was the desire of the owners to make the interior of their restaurant pleasantly modern and with individual characteristics of its own rather than to merely have it represent a production plant where hastily prepared meals are served in rapid-fire fashion.

Large area panelled lighting elements were employed. These elements were arranged in accordance with the restaurant layout plan. Rectangular elements 4 x 6-foot in size were placed over each of the "U" shaped counters. A 72 foot long by 16 inches wide continuous run was arranged over the table area which extended the full length of the room. The lighting elements were designed to use slimline lamps, 72-inch lamps over the counters and 96-inch lamps over the table area. The lamps are adequately shielded from all angles by the cellular louvers which provide 38° shielding both parallel and transverse to the lamps. The vertical sides of the lighting elements are illuminated by reflected light so there is no undesirable contrast with the well lighted ceiling.

It was the owners' wish in their "good housekeeping and cleanliness policy" to have the food preparation area in plain view of their clientele. They went one step further in illuminating this area to a high intensity for the dual purpose of making it easy for the customer to see his food being prepared as well as for the benefit of the

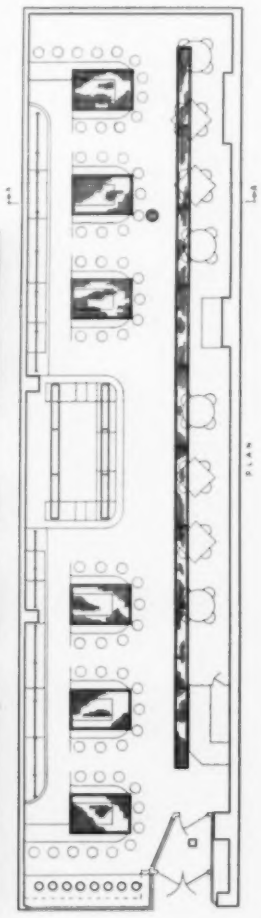


Figure 2. Lighting plan and close-up view of 4-ft x 6-ft lighting elements over "U" shaped counters, soffit lighting over pastry display area and intensified illumination in the "open" kitchen.

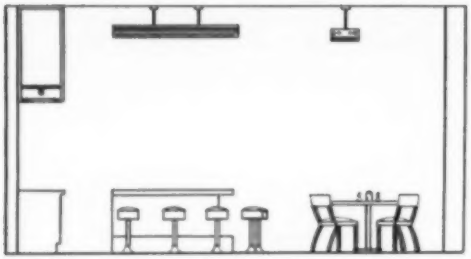


Figure 3. Section through serving area and display counter.

staff, who are required during rush hours to work at a comparatively high rate of speed.

In keeping with the principles of good merchandising, that the merchandise must be seen by the customer to be sold, local lighting in the form of fluorescent lamps behind sanded glass panels has been placed over the pastry displays. These displays are located along one wall of the room behind the counters and are always in view of the customer. This provides part of the attraction or display lighting, one of the principle functions of store lighting.

As a part of the owners' policy of keeping the establishment clean, the maintenance of the lighting equipment was given special consideration. Small cell louvers present a problem in cleaning. This had some influence on the selection of disposable fibre-board louvers for the lighting elements. It is believed that the disposable louvers can be replaced at approximately the same cost as the labor for cleaning conventional louvers with the additional advantage of a completely new element in the lighting units. The owners also feel that the slimline lamps have advantages from a maintenance standpoint.

AN EXAMPLE of the "leisure" type of restaurant, where illumination levels are kept at moderate values (in this case 12 footcandles). Restaurant shown is the Town Room of the Copley Plaza Hotel, Boston, Mass., using 150-watt recessed louvered downlights, cold cathode cove lighting, and illuminated glass wall panels. Architect was Mrs. Mary E. Kennedy; engineer, Henry Klopot of Boston. Photo courtesy Boston Edison Co. through Boston Electric Institute.

What Is Comfortable Lighting?

By L. C. KALFF

The author's views of lighting application should be of interest to everyone in the lighting field. Unlike most of us, Mr. Kalff's work takes him to every part of the globe; he therefore has a rare opportunity to assess the relative work of those who design and install lighting and their basic objectives. After attending the National Conference in Boston, Mr. Kalff spent several months travelling in the United States.

MANY of the thoughts we have written down here have come to us after visiting the Paris Congress of the I.C.I. last summer and after attending the National Technical Conference of I.E.S. in Boston in September. The I.E.S. is an excellent organization, doing admirable work and we only regret that local circumstances and difficulties in Europe do not make such unity and constant work possible over here. We do think, however, that the general trend of work being done on lighting development in the States as well as in Europe, is a bit too one-sided on the side of the engineer, and that this engineer is slightly over-interested in immediate results. Perhaps our remarks may stimulate some of them to take an interest in those things here described.

Only a few years ago the only concern of the lighting expert was to plan efficient lighting systems. When we say *efficient lighting systems*, we mean systems that are not too expensive in initial and running costs in relation to the work that is to be done under their light.

First we thought that the most efficient lighting system had a uniform lighting level on the working plane. Then we found that uniformity was not the only quality we had to look for; there were, indeed, seeing tasks for which too great a uniformity could be uncomfortable. Slowly we have found, with the development of new light sources, that a great many specifications are necessary in order to obtain effective lighting systems for different visual tasks. All of these specifications had one particularity in common, however. They were all designed to avoid discomfort. We found that it was necessary to avoid eye-fatigue, to avoid glare, to avoid marked contrasts in brightness. It is quite understandable that the lighting expert, avoiding all these discomforts, comes to the conclusion that this lighting system in the end will be comfortable. We think that there he has made a fundamental mistake.

Nowadays we speak of comfortable lighting without having given a clear definition of what we mean by that word. One does not create comfort by taking away discomfort. We think, therefore, that it is erroneous to speak of "comfortable lighting" in the sense it is used today. The appraisal of modern lighting systems reminds us of the arguments cigarette manufacturers use for their products. On many packages of cigarettes and tobacco we find the words: "This tobacco does not contain any harsh or irritant components."

If we draw another parallel, we might say that the medical and chemical expert is not the person to prepare a nice tasteful and pleasant dinner. He may be able to concoct a food in which all the necessary nutrition, vitamins and calories are put together.

We know that if others have not spoken much about what comfortable lighting really is, they have had one very good reason in the fact that it is extremely difficult to give a good definition. In giving this definition we realize that there are many factors which are so difficult to handle, especially for a technical man, that he would rather be silent about them. By this we do not want to give the impression that the tremendous and very valuable work that has been done up till now to abolish discomfort and develop new lighting systems, is negligible. However, the moment it becomes obvious that there is something beyond efficiency and absence of discomfort, that the value of a lighting system can better be expressed in brightness than in footcandles, and that the study of these brightnesses leads to brightness-engineering, the lighting expert has already admitted that creating lighting is not a mere question of making an adequate lighting system. Here the difficulty really begins. For the moment we want to create for our visual field a certain satisfactory distribution of brightnesses, the problem becomes a combination of lighting problems and problems for the interior decorator. Materials, colors and surfaces will have to be chosen. The lighting expert has tried to find out which values of brightness-contrast are admissible and has again found threshold values which give him a safe margin. As he cannot include colors and textures in his measurements and calculations, he is more or less afraid to mention these very important factors

MR. KALFF is General Art Director, Philips Works, Eindhoven, Holland.

in the creation of a comfortable picture for the eye. The interior decorator will be inclined to mistrust the lighting expert because he cannot get all-round advice from him on the subjects which he considers the most important for the conception of his interior.

Lighting men have often given a wrong impression by omitting to stress the fact that the recommendations should be considered "for good lighting practice under the given circumstances" *i.e.*, with the given technical and economical development of the country in which they work .and that it is logical that these recommendations may change if the circumstances change. For that reason it is quite understandable that people protest against new recommendations that are different and often considerably higher in illumination levels than the old recommendations. They think that the recommendations should be standards for many and many years; instead of that, actually they are more or less inspired by technical or commercial possibilities and wishes. It would be of great benefit, therefore, to find an ultimate target for these recommendations of illumination levels, or rather brightnesses, giving real comfort whilst providing for the different visual tasks. These ultimate targets may be more or less vague, especially in regard to the age of the observers, but since everybody can experiment and find really comfortable conditions during daylight, it would be foolish to deny that these standards for comfortable levels exist.

We are aware that what we are writing about now is, to a great extent, inspired by our own feelings on the matter and that an enormous amount of work must be done before a more precise definition of what we mean can be given. Nevertheless we think it worthwhile to make our thoughts known to a wide circle of colleagues in order that they may think over these problems and express their opinions also.

Comfortable lighting should result in a comfortable sensation when looking at one's task. This comfortable sensation can be obtained only if the whole picture in our visual field is comfortable. As a first sketchy try, we should like to propose different factors and conditions necessary for such comfort:

(a) The brightness of the actual task we feel to be satisfactory for seeing it; and we should like to fix this brightness by examination of a great number of observers of all ages, who are interested in that kind of work. These observers should find their own personal preference for reading fine print, taking into account the other following factors.

(b) The brightness, pattern, colors and extension of the immediate surroundings of the actual task should be found during the same experiments with the same observers.

(c) The zones of the visual field outside the actual surroundings should be conducive to concentrating the attention on the visual task and its immediate surroundings. This is a positive action, so that we should endeavor to find the conditions for this action and not only limit ourselves to the elimination of uncomfortable factors such as glare, too great brightness and brightness contrasts.

(d) The whole picture of the visual field should be a composition in which the distribution of brightness, colors and surface textures work together, in order to concentrate the attention of the observer on the task itself, but we must not forget that there may be a secondary center of attention, on which the eyes may focus during the intervals of rest when one looks up from a regular task.

(e) It should also give an impression of pleasantness, well-being, even beauty.

The factors (a), (b), (c) and part of (d) may some day have a clearer definition through independent work of technicians and scientists on experiments of the kind we mentioned. It seems obvious, however, that during many of these experiments not only vox populi will be the only means of getting the answer to our questions, but the help of creative artists and trained men of taste will be necessary also, in order to avoid the mistakes already often made. Factor (e) is almost completely the task and privilege of the interior decorator, the architect or the trained man of taste. Here collaboration becomes very necessary although it may be difficult to find the best procedure for getting this collaboration.

We may, perhaps, draw a parallel with good paintings, considering the motives of the artist. The artist will conceive a center of interest or a center of gravity in his painting and emphasize it by using in those spots the highest brightnesses, the biggest contrasts and the most emotional colors. He will perhaps unconsciously divide his picture into different zones of interest, using lower brightnesses, lower brightness-ratios and less emotional colors in those parts of the picture that are farther away from the center of interest.

Portraits to illustrate this may be found in many museums. Take, for instance, famous portraits by Holbein, Memlinck, Dürer, Eick and so many others. Often only the face is the interesting part of the picture. Sometimes the hands, with the face, form a triangular center, along which the eye wanders during observation. These faces and hands have the brightest surfaces, the warmest colors and the greatest linear expression. In many cases they are surrounded by dark zones of hair, clothes, hats and such, whilst the background is much more vague with less detail, in cooler colors of gray, blue or green.

Later portraits often follow similar lines. Van Dijk, Rembrandt, El Greco, Rubens, will illustrate this, but also famous interiors by Vermeer or land-

scapes by Hobbema, Wouwerman and Ruysdael show the same lines of thought.

Let us describe an ideal classroom as follows:

A teacher is sitting in front of a class, explaining a lesson. The attention of the pupils must be concentrated on her. She should be, therefore, the brightest spot in their field of vision and the most interesting item. The ideal case will be that she is pleasant to look at, has a good dress in a light but warm color. Her immediate background should be considerably less bright and in cooler colors, so the front wall of the classroom may be painted in a pleasant blue-green, which is a cool and receding color. The teacher's dress may be shiny, perhaps a satin pink or red blouse; the wall should be matte. The ceiling and the side-walls should be considerably darker and have nothing to distract the attention from the center of the scene. For that reason, the side-walls may be painted in a dull green and the ceiling, which in order to create a pleasant atmosphere and to make possible soft shadows, may be white. But the lighting system in this case should leave the ceiling almost completely dark.

It is clear that looking at the teacher is not the only visual task to be accomplished in a classroom. Other lighting conditions should be provided, so that reading or writing at the desks is also an agreeable task. For that reason we think that the desk-tops also should have a light and warm color, say leather-brown, and the floor should be darker than the desk-tops and cooler in color, gray for instance.

We are fully aware that in visualizing such a classroom we are describing many things that concern the interior decorator and even the teacher's personal taste and her dressmaker's, but we think it useful to do so, because we do not believe that the creation of comfortable lighting is possible without the collaboration and mutual understanding of all those who by their work have an influence on the picture the pupil in the classroom will see.

In describing the ideal picture for concentrating on the task in the classroom we do not want to imply that this kind of concentrated picture is the only one and that other pictures and a different distribution of zones may not be necessary. For instance in a restaurant, the center of interest is partly the table-top and the food, and partly the horizontal zone within which we see the faces of our friends around the table and of the other persons in the room.

Summary

We believe that it must be possible in the near future, in the first place to set a final target for all lighting standards and recommendations, and further to get a better understanding of what the collaboration between lighting expert and architects and decorators should involve. As we have said, the ultimate efforts necessary for obtaining ideal conditions are the task of the creative artist. They cannot be the result of reasoning.

The mass production of light sources in America is in many respects ahead of the developments in Europe, but we do not think that modern lighting applications in the States, though very much more numerous than in old countries, are technically very much ahead of lighting practice here (Holland). Although Europe is at a disadvantage by being split up into so many countries and races, this fact also has an advantage in the independent and individual developments in lighting practice that may be found in several of them. We find not much difference in lighting practice, traveling from Boston to New York; Cleveland to Chicago. If we cover the same distances in Europe, however, we find completely different trends in Stockholm, Copenhagen, Amsterdam, Brussels, Paris, Zürich, and Milano, due to the very big differences in climates, races, political circumstances and taste.

Lighted Alcove for Arranging Flowers

How a closet or alcove outside the kitchen can be made into a useful and decorative garden room is suggested in one of the alcoves of the new Sylvania Lighting Center.

Lighted shelves on either side of the cabinet, which holds pots and garden equipment, compose the alcove, and the shelves are back-lighted by means of a concealed 20-watt fluorescent lamp placed vertically along each shelf section. For general illumination, a shielded single-lamp fixture containing a 20-watt fluorescent tube, is attached to the ceiling and provides uniform light on the work surface. Niches for displaying flowers, so that the housewife can judge how they will appear at a flower show, are set into both side walls and are illuminated by 60-watt incandescent bulbs shielded by glass panels. Particularly important because of the increase in garden club activities, such an alcove permits a woman to arrange flowers without dirtying the entire house.— *Photo courtesy of Sylvania Electric Products Inc.*

Inspection Lighting for the Dry-Cleaning Industry

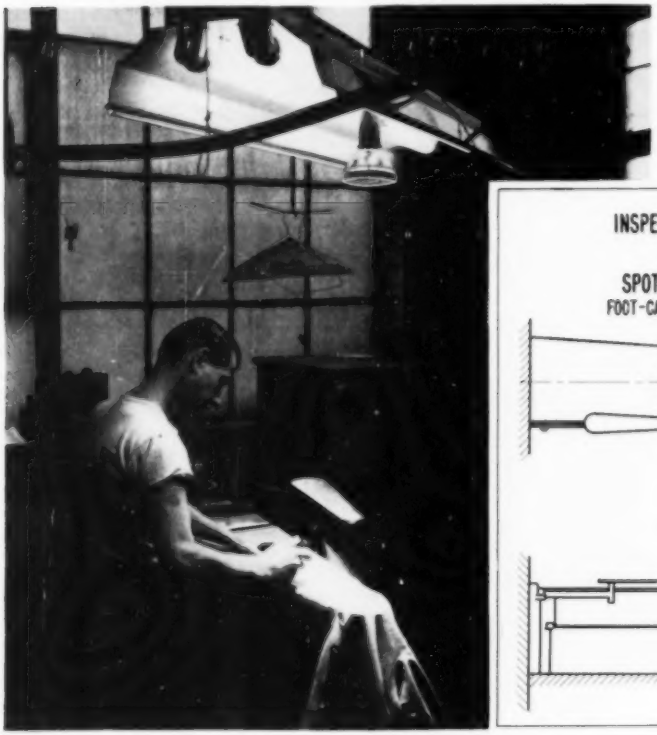
By J. F. FINN

INSPECTION of garments presents one of the most difficult visual tasks encountered in the dry-cleaning industry. The lighting methods usually employed at the spotting boards and final inspection centers have not been designed to meet the specific needs and have not sufficed to reveal low-contrast spots on garments. If a spot or stain has not been removed, the customer simply considers that the garment has not been cleaned and the time and money expended by the dry cleaner is lost. Return of garments because of faulty spotting is a major problem for which the cleaning industry badly needs a solution.

A paper presented before the Michigan Section, Illuminating Engineering Society. Mr. FINN is with the Lighting Division, Detroit Edison Company, Detroit, Mich.

It is interesting to follow the dry-cleaning process and note all the work that may be nullified if the inspection is not satisfactory.

In the regular process of cleaning, the garment goes first to a marking table, then is sorted as to color and weight. Next it is put through the regular cleaning process, followed by deodorizing. The spotter then examines the garment for spots that may not have been dissolved by the solvents in the cleaning process. These spots may be of a fatty acid, such as butter or lard, or of tannic



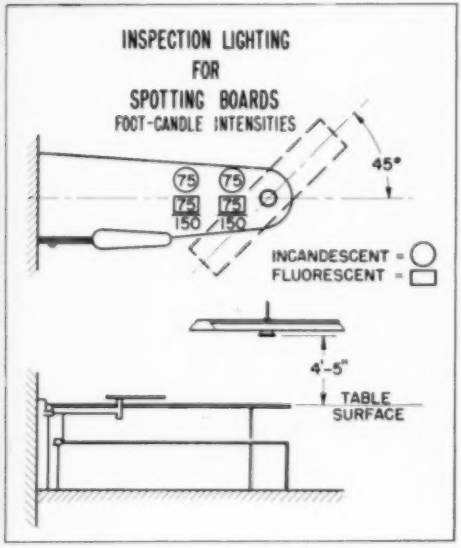


Figure 1. While the level of illumination on spotting boards, here 150 footcandles, is of primary importance in the visibility of spots of low contrast to surroundings, the color mixture provided is also of value.

acid, as in coffee or coca cola. Sometimes the detergent in the cleaning process only loosens the outer rim of the spot, and the body of the spot may still be easily discerned. The spotter then applies live steam and a chemical agent, if necessary, to remove it. When the spotter passes the garment, it is apparently free from any spots and it goes next to the presser, where it is formed and pressed.

Now, comes the final inspection center. The garments are hung on pipe-distribution racks, and, in most dry-cleaning plants, every square foot of floor area is utilized. Working space is most confined, even though more than one inspection center is set up in modern plants — one for light materials and the other for heavier materials. In other words, the inspector is located in an area almost enclosed by garments. The inspector takes the garments from the incoming rack and inspects each one individually, on what is called a slick rack.

Generally, two 40-watt fluorescent lamps housed in an industrial reflector are mounted over the garment to be inspected. The garment is passed on to the finished rack if no spot is detected. Then it is delivered to the customer. However, spots which were not apparent under this two-lamp 40-watt fluorescent inspection source may become apparent under daylight conditions, and, as far as the customer is concerned, the cleaning and inspection of the garment are unsatisfactory.

Work on this problem during the past year has brought about a solution that will minimize such complaints. A study was made of garments passed

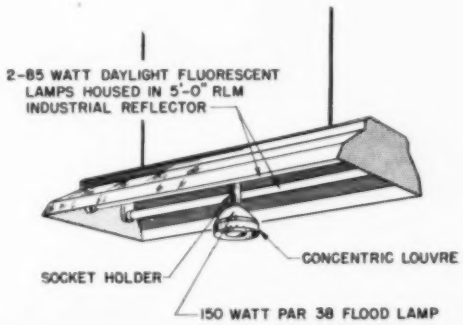
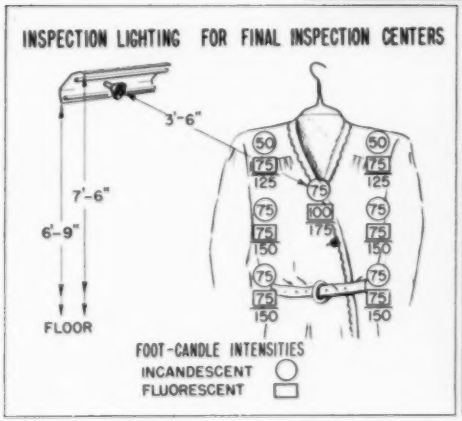


Figure 2. Upper right. Details of the final combination of lighting sources selected for the inspection of dry-cleaned garments. Addition of concentric louver shown raised the illumination reading 2 footcandles.

Figure 3. The 150-watt Par-38 floodlamp is focused over the left shoulder of the inspector, never over the head or body.



by the inspectors but returned by customers. Materials affording most difficulty are: crepe, gabardine, and taffeta. Stains that are most difficult to work with are: coffee, coca cola, tea, milk, icecream, egg and fatty acids. In the plant in which this study was conducted garments had been examined under an average of 30 footcandles. For five months, many light sources and colors were tried, with various mounting heights.

Under actual working conditions obtaining in the plants studied it was found that the optimum level of comfortable lighting was in the neighborhood of 150 footcandles. At higher levels of illumination the brightness of the materials being inspected became undesirably high in relation to the surrounding area served only by the general illumination.

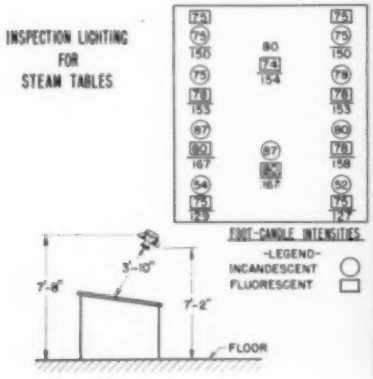
The final combination selected was two 85-watt daylight fluorescent lamps housed in an RLM industrial reflector and a 150-watt PAR-38 floodlamp equipped with a concentric louver for shielding the light source. These provide reasonably uniform illumination over the top half of the garment, with the fluorescent and filament sources each contributing about 75 footcandles. The addition of the louver shown in Fig. 2 raised the reading two footcandles.

In the inspection process shown in Fig. 3, the problem appeared to be more one of supplying enough light rather than reproducing skylight in color, as spots of low contrast to surroundings became more visible upon raising the illumination level to 150 footcandles. (See also Figs. 1 and 4). However, the colors of the garments examined under this color mixture have more warmth and became more easily identifiable than under other combinations of higher footcandle values.

The reason for this effect is that small color differences are more apparent under light which is the complement of the material. Thus, the addition of filament lighting which is rich in the red and yellow wavelengths improves the visibility of spots particularly on the blue and gray materials. Conversely, the blue-rich fluorescent sources give good visibility for the warmer colored fabrics —reds, browns, etc. An indication of the success of this solution of the lighting problem is found in the record of one cleaning plant which had been experiencing an average of ten garments a week returned by customers. Since the installation of these units, there have been no garments returned due to "washed-out" spots.

Two problems require further attention in order to achieve a completely satisfactory lighting condition: One is the avoidance of glaring reflections from materials having pronounced sheen; the second is the minimizing of radiant heat from the light sources.

Figure 4. The combination daylight fluorescent lamps and 150-watt Par-38 floodlamp gives good visibility for inspection lighting at steam tables, both as to illumination level and to color contrast for almost imperceptible spots.



The New Approach to Room Lighting

By PARRY MOON

To achieve an ideal luminous environment, the illuminating engineer must be able to predict whether the design will be satisfactory visually and psychologically. Using this theme, the author presents his case to electrical engineering students at the Massachusetts Institute of Technology. It seems certain that his remarks are of interest to all engaged in lighting work.

AS WE look about us today, we can hardly fail to realize that we are in the midst of a *lighting renaissance*. Not only have lamps and luminaires been revolutionized within the last decade, but — what is perhaps more important — our whole attitude toward room lighting has been transformed.

The traditional way of lighting a room was to install concentrated sources that squirted light onto the work. The sole criterion of excellence was the amount of light received on the "working plane." If the lightmeter gave a high reading, the installation was considered successful, regardless of the glare, shadows, and eyestrain that might result.

The new idea, on the contrary, is that lighting should consist in the creation of a *luminous environment* for human beings. The system is installed for people, not for lightmeters; consequently, it is not ideal unless it satisfies all the complex human requirements associated with a luminous environment. Walls, ceiling, floor, furniture — everything in the room is important. All these surfaces should send light to the eye, and the color and distribution of this light determines the human effectiveness of the design.

I shall attempt to give a broad survey of recent developments in room lighting. There will be nothing erudite in this treatment and nothing essentially new. I hope, however, that such a survey will help us to correlate the diverse factors that enter the problem and to orient ourselves in the direction of real progress.

Calculation of Light

To design an ideal luminous environment, the illuminating engineer must consider two factors: the calculation of light, and the establishment of criteria. That is, he must be able to predict what a proposed design will do, and he must know from his calculations whether the design will be satisfactory visually and psychologically. Unless both of these steps can be realized, a great deal of time and money will be wasted in installing unsatisfactory lighting systems and in tearing them out and replacing them by others that are almost as bad.

Turning first to the question of light calculations, we find that classical methods are completely inadequate to meet modern needs. The inverse-square law (and other mathematical relations based on it) satisfied Lambert in 1760 and have been copied in all the books down to the present day. The inverse-square law, to be sure, is a beautifully simple and direct relation. The only trouble is that it has absolutely no bearing on modern room lighting. In the first place, it applies rigorously only to a source that is a mathematical point, and by no stretch of the imagination can one consider an eight-foot fluorescent lamp as a point. Also, it and all classical methods of calculation assume that light always commits suicide when it hits a surface. Actually, we know that it is very much alive. It bounces off the surface, strikes the ceiling or walls, and is reflected again.

Figure 1. A classroom lighted by a luminous ceiling of diffusing plastic. Forty-four 72-inch T-8 fluorescent lamps (4500°K), above the translucent plates, require 3.26 watts per square foot and give approximately 60 ft-c (L/ft²) at desk level. A 2:1 brightness ratio is obtained between the ceiling and white paper on the desk, so both direct and reflected glare are eliminated. The visual effect is not ideal, however, because of the dark chalkboards and furniture, which were not changed when the room was relighted.

Presented at Electrical Engineering Colloquium, Massachusetts Institute of Technology, December 1, 1948. PROF. MOON is Associate Professor at M.I.T., Cambridge, Massachusetts.

Particularly in a modern room, with its white ceiling and light-colored walls and floor, a large proportion of the light we use does not come directly from the luminaires but is the result of *interflections* among the various room surfaces. These interflections cannot be neglected if the true light distribution (or even a rough approximation to it) is to be calculated, yet all classical treatments ignore interflections. Thus before room lighting can take its place as a branch of engineering, we must have a method that considers the infinite number of interflections occurring in a room.

Fortunately, such a method was discovered in 1927 by H. Buckley.[1] He found that interflections within any enclosure can be expressed by means of an integral equation.* Everything in this equation except H is known or can be calculated by elementary methods. The solution of the integral equation consists in finding the function H. The method can be extended to the general surface where a point is specified by two variables instead of one.

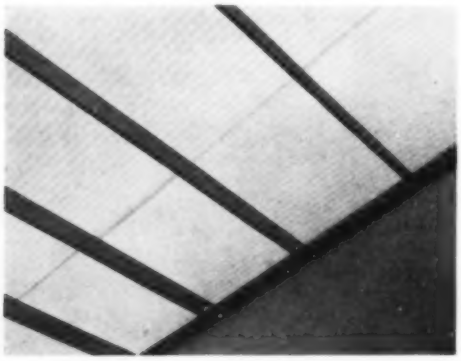
The integral equation for the rectangular room was solved a few years ago,[2] and the results have been tabulated.[3] These *interflection tables* have appeared in reports[4] of the Committee on Standards for Quality and Quantity of Interior Illumination and in books[5] so they are readily available. They allow anyone to find, in a few minutes, the light distribution in a room lighted by any proposed system. The tables give not only the average light at table level, but also the brightness (helios) of walls, ceiling, and floor. Thus the first requirement for an engineering treatment of the luminous environment is solved.

*If the enclosure has sufficient symmetry so that a point can be specified by a single variable s then the integral equation is:

$$H(s) = H_0(s) + \rho(s) \int K(s, t)\, H(t)\, dt$$

Where $H(s)$ = brightness (helios), including interflections, of the enclosure at a point designated by s,
$H_0(s)$ = brightness (helios) at s with no interflections,
$\rho(s)$ = reflectance of surface at s,
$K(s, t)$ = kernel of integral equation
= incident illumination (pharosage) at s, caused by luminous element at t, per unit $H(t)$, per unit t.

Figure 2. View of the ceiling, showing the perforated steel supporting beams containing acoustic absorbing pads. The beams are 6 inches deep and are spaced on 36-inch centers. The $\frac{1}{8}$-inch plastic sheets rest on the beams and are easily removable for cleaning and relamping. The sheets are corrugated for greater stiffness.



Criteria

This brings us to the second factor: criteria for good lighting. How can the illuminating engineer predetermine whether his proposed design will be visually satisfactory? It seems that progress in criteria may be divided into three steps:

(a) Amount of light ("footcandles" as sole criterion)
(b) Visual criteria (visual acuity, etc.)
(c) Criteria involving the whole organism

In the early days of lighting, *amount* of light was the sole criterion, and perhaps rightly so. It was a hard struggle to get enough light; and refinements, such as consideration of shadows and glare, were subordinated. But modern light sources allow adequate lighting, and fixture salesmen who still employ criterion (a) are finding rough going. This is particularly true because the eye becomes increasingly intolerant of glare as the level of visual adaptation is raised. A brightness ratio (helios ratio) that is accepted without question in candle lighting (10 lumen m^{-2}) becomes intolerable at 50 L/ft^2 (500 L/M^2).

So there has been an increasing use of criteria (b) and (c). Purely visual criteria, such as those based on visual-acuity research, give definite information on the effect of brightness (helios) and of non-uniformity in the visual field. In (b) the accent is still on the central field. But it is well known that the peripheral field is vital in the overall response of the individual. Color and distribution in the entire visual field are important physiologically and psychologically. Strong advocates of (c) are Harmon[6] and Logan.[7]

The production of an ideal luminous environment requires the simultaneous consideration of (a), (b), and (c). Visual-acuity tests, because they are among the most definite and precise of tests on seeing, offer important information. This information should be supplemented, whenever possible, by more subtle investigations. At present, however, we cannot rely entirely on the latter because they yield only qualitative (or, at best, roughly quantitative) information.

Lythgoe's data, amply substantiated by the work of Hecht and his collaborators, and by Stiles and Crawford, show that with a uniform surround, *vision continues to improve as light is increased,*

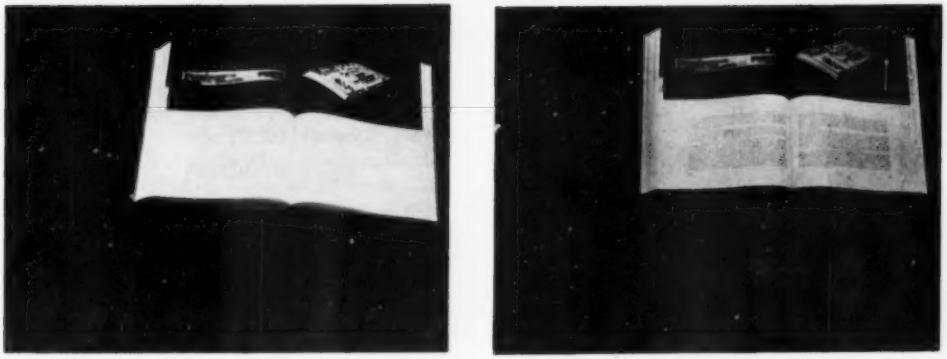


Figure 3. A book resting on the arm of a chair in an M.I.T. classroom. (A) Room of Figure 1, lighted by luminous ceiling. (B) Another room, lighted by louverall ceiling with 40-watt, 60-inch T-17 fluorescent lamps. Note specular reflections of lamps in book and furniture. Such reflections are undoubtedly the cause of much of the eyestrain encountered with conventional lighting systems. If the 3:1 criterion is satisfied, this trouble will be eliminated.

up to daylight values.[8] That is, there is no optimum value — the more light we use, the better we can see. Thus the amount of light is largely an economic consideration; and as lamps are improved, we can afford more light and we will use more light.

Another interesting result of Lythgoe's research is that a non-uniform surround has little effect on visual acuity at low adaptation levels but becomes increasingly deleterious as the amount of light is increased.[9] The conclusion is that the entire environment must be reasonably uniform if ideal visual conditions are to obtain. Of course, actual rooms cannot be made perfectly uniform in brightness (helios), and if they could we probably would not want to live in them. Further research indicates that a 3:1 brightness (helios) variation is satisfactory, and the Illuminating Engineering Society has advocated that this ratio be not exceeded for best results. That is, the brightest surface in the room should not be more than three times as bright as the work, and the work should not be more than three times as bright as the darkest surface in the room.*

The exact value of 3 is, of course, somewhat arbitrary because of the wide adaptability of the eye. One might choose 2 or 5 or any other small number. What we definitely do not want are the ratios of 20 or 100 or 1000 that are still common.[7] The most obvious defect in existing lighting systems is excessive contrast, excessive brightness ratio. A low ratio automatically gives well-diffused light, freedom from shadows and glare, and a pleasing psychological effect. Further research is needed on the influence of color and on the exact light distributions that will give the most pleasing modeling or three-dimensional effect. These may be considered as "second-order effects," however, for *the single criterion of a 3:1 ratio appears to be sufficient to guarantee an ideal luminous environment*, assuming of course that a reasonable amount of light is provided.

*A rigorous statement requires the use of the concept of *adaptation helios*. The above statement, however, is good enough for most purposes.

Preferred Lighting Systems

We now have considered the interflection method of calculating light and the 3:1 criterion. There remains the question of how to apply these factors in the design of ideal lighting systems. What general type of lighting will satisfy the 3:1 criterion? We can discard immediately any kind of bare lamp (even fluorescent lamp, louvered or unlouvered), also downlights, lens plates, prismatic luminaires, diffusing globes, troffers, and the louverall ceiling (Table I). Analysis by means of interflection tables[3] shows that ordinarily the only possibility is *ceiling lighting*. And even with this type of lighting, the 3:1 ratio is satisfied only when sufficiently high reflectances are employed.

To summarize the results of this investigation, we may say that for best visual conditions we should use

(a) Ceiling lighting
(b) White ceilings with reflectance of at least 0.80
(c) Wall reflectances of 0.50 or more
(d) Floor and furniture with reflectances of at least 0.30
(e) All large areas with Munsel chroma of 4 or less.[10]

These specifications guarantee an ideal luminous environment and best possible conditions for seeing. They are, therefore, the conditions that should be satisfied in schoolrooms, offices, libraries,

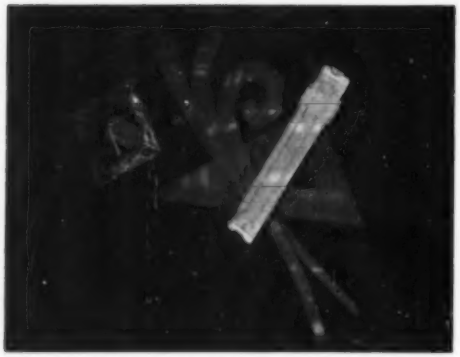


Figure 4. Another example of reflected glare caused by the louverall ceiling mentioned in Figure 3(B). The annoying lamp images are banished when the uniform luminous ceiling (described in Figure 1) is employed.

and drafting rooms. Obviously they need not be met where the visual task is not severe and where the designer wishes to create a special effect, for instance in a theater, a lobby, or a nightclub.

Ceiling Lighting

Ceiling lighting can be obtained in two ways: by *reflection* and by *transmission*. If reflection is chosen, the ceiling is painted white, and light is directed upward to it from below. Such indirect systems have been employed for many years. Ordinarily, however, they have been neither efficient nor pleasing, because of the use of traditionally low reflectances. By employing the high reflectances recommended above, we eliminate this difficulty. A wide variety of methods is available for illuminating the ceiling, including coves, wall boxes, hanging luminaires, and indirect floor lamps. This type of lighting is relatively inexpensive and, if properly done, with high reflectances and with luminous-indirect fixtures that match the surfaces against which they are viewed, the effect is similar to that obtained with the transmission method.

In the transmission method, the lamps are mounted on the ceiling, with a hung ceiling of translucent material below them. The lamps are completely hidden from view; and the apparent source of light is the hung ceiling, which constitutes a diffuse surface of large area and low brightness (helios). Acoustic treatment can be incorporated into the supporting structure or can be applied to the walls. Modern acoustic research proves that either is more effective than the old way of covering the ceiling with acoustic tiles which absorb some sound and a great deal of light. Because of the absence of hanging fixtures, the transmitting ceiling gives an impression of admirable simplicity and spaciousness. The cost, however, is higher than for the reflection method.

Undoubtedly the cost of luminous ceilings can be reduced as more experience is gained in making them. An experimental ceiling, installed in a classroom at Massachusetts Institute of Technology,* resulted in the costs listed in Table II. The lighting system consisted of forty-four 72-inch T-8 (4500°K white) fluorescent lamps with two-lamp ballasts, operating at 200 ma, mounted on the structural ceiling. Approximately 18 inches below are perforated steel beams containing acoustic material. On these beams rest the sheets of diffusing plastic. The total power is 2200 watts or 3.26 watts per square foot. The average illumination (pharosage) at table level is approximately 60 ft-c (L/ft^2).

As shown in Table II, the total cost of lamps, ballasts, and wiring (done by an outside contractor) was $1125, or $1.67 per square foot. The supporting structure, including acoustical material and installation charges, was $597, or $0.89 per square foot, while the $\frac{1}{8}$-inch diffusing plastic cost $1.43 per square foot. The total cost per square foot was $3.99, which is less than that of a louverall ceiling ($4.50 estimated).

How can the cost of a luminous ceiling be made comparable with that of conventional luminaires? For a given amount of light, the lamps, ballasts, and wiring are essentially the same, irrespective of the type of lighting. The complete supporting structure, with acoustical treatment, costs little more than the 60 cents per square foot needed for covering the ceiling with absorbing tiles. The difference is probably compensated by the fact that luminous-ceiling lighting employs no reflectors or other fixtures. The $1.43 for plastic, however, can

*The lighting was designed by the M.I.T. Lighting Committee and the acoustic treatment was done in collaboration with the M.I.T. Acoustics Laboratory. For data used in this paper, I am indebted particularly to Herbert L. Beckwith and Carl M. F. Peterson.

Figure 5. Reflected glare caused by louverall ceiling.

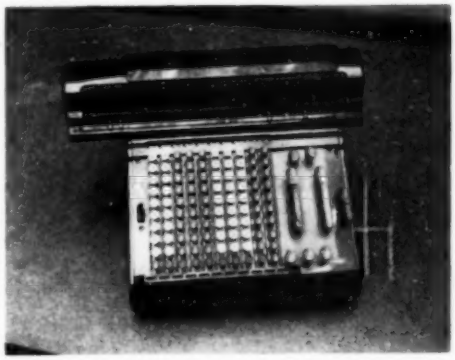


Table I

Fluorescent Lamps (bare or louvered) do not satisfy the 3:1 criterion!

Lamp	H (blondel)	B (footlambert)	Brightness (helios) ratio*
40-watt T-12 (4500°K)	17,300	1610	43.3
40-watt T-17	9,900	920	24.7
100-watt T-17	18,900	1760	47.2
96-inch T-8,			
at 200 ma	17,700	1650	44.2
at 300 ma	23,200	2150	58.0
32-watt circular lamp (3500°K)	22,000	2040	55.0

*For incident illumination (pharosage) of 500 lumen m^{-2} (46.5 lumen ft^{-2}) on white paper having a reflectance of 0.80.

Table II

Cost of Installing an Experimental Luminous Ceiling

Floor area = 675 sq. ft. Ceiling height = 15 feet

	Cost	Cost per square foot
Lamps, ballasts, and wiring	$1125	$1.67
Acoustic beams fabricated and installed	597	0.89
Diffusing plastic	968	1.43
Total	$2690	$3.99

certainly be reduced. Thin plastic sheets held in light metal frames are a possibility, and several rooms at Brown University are using luminous ceilings made of renewable treated paper costing only 1.4 cents per square foot. Further investigation of these practical details is desirable.

Summary

Ideals in room lighting have changed from the old criterion of "footcandles" to the new idea of creating a *luminous environment*. The modern idea therefore puts paints on a par with lamps and requires the consideration of brightness (helios) distribution in the whole field of view.

Classical methods of calculating light are found to be inadequate and are supplemented by the *interflection method*, while multitudinous criteria are boiled down to the simple 3:1 rule. If this rule is satisfied, glare, shadows, and other troublesome factors are automatically taken care of, and ideal visual and psychological conditions result. Further analysis shows that the best way of satisfying the 3:1 ratio is to use a luminous ceiling, with high reflectances and low chromas for walls, floor, and furniture. It seems that the illuminating engineer has at last formulated the basic requirements for ideal room lighting.[11] Further refinements may be desirable and practical details must be worked out, but the fundamental principles in the production of a luminous environment are here to stay.

Bibliography

1. Buckley, H.: "On the Radiation from the Inside of a Circular Cylinder," *Philosophical Magazine*, Vol. 4, 1927, p. 753.

2. Moon, Parry: "Interflections in Rooms," *Journal of the Optical Society of America*, Vol. 31, 1941, p. 374.

3. Moon, Parry, and Spencer, D. E.: "Light Distributions in Rooms," *Journal of the Franklin Institute*, Vol. 242, 1946, p. 111. "Lighting Design by the Interflection Method," *Journal of the Franklin Institute*, Vol. 242, 1946, p. 465.

4. "The Interflection Method of Predetermining Brightnesses and Brightness Ratios," Report No. 3 of the Committee on Standards of Quality and Quantity of Interior Illumination, ILLUMINATING ENGINEERING, Vol. XLI, No. 5, p. 361 (May, 1946).

5. "Brightness Distribution in Rooms," Report No. 4 of the Committee on Standards of Quality and Quantity of Interior Illumination, ILLUMINATING ENGINEERING, Vol. XLII, No. 2, p. 180 (February, 1947).

5. *I.E.S. Handbook*, Illuminating Engineering Society, New York, 1947.

Lighting Design, Addison-Wesley Press, Cambridge, Mass., 1948.

6. Harmon, D. B.: "Lighting and Child Development," ILLUMINATING ENGINEERING, Vol. XL, No. 4, p. 199 (April, 1945).

7. Logan, H. L.: "Specification Points of Brightness," *I.E.S. Transactions*, Vol. XXXIV, No. 8, p. 881, (September, 1939). "Light for Living," ILLUMINATING ENGINEERING, Vol. XLII, No. 3, p. 291 (March, 1947).

8. Moon, Parry, and Spencer, D. E.: "Visual Data Applied to Lighting Design," *Journal of the Optical Society of America*, Vol. 34, 1944, p. 605.

"The Visual Effect of Non-Uniform Surrounds," *Journal of the Optical Society of America*, Vol. 35, 1945, p. 233.

9. Lythgoe, R. J.: "The Measurement of Visual Acuity," *Medical Research Council*, Report of Committee upon Physiology of Vision, London, 1932.

10. Moon, Parry, and Spencer, D. E.: "The Color of Unstained Wood," *Journal of the Optical Society of America*, Vol. 38, 1948, p. 405.

"An Engineering Correlation of Room Colors," *Journal of the Franklin Institute*, 1949.

"A Survey of Colors for Industry," (Not yet published).

11. Ainsworth, George: Discussion, ILLUMINATING ENGINEERING, Vol. XXXVI, No. 10, p. 1047 (December, 1941).

Brainerd, A. A.: "Achievement of Poise in a Lighting System," ILLUMINATING ENGINEERING, Vol. XL, No. 7, p. 455 (July, 1945). Spencer, D. E.: "Classroom Lighting," ILLUMINATING ENGINEERING, Vol. XLIII, No. 7, p. 743 (July, 1948).

Mowry, W. S., and Spencer, D. E.: "Louvered Ceilings—Fact or Fad?" *Electric Light and Power*, Vol. 26, p. 100 (September, 1948).

Spencer, D. E., Buck, W. H., and Wolfson, A. A.: "The Fallacy of the Louverall Ceiling," ILLUMINATING ENGINEERING, Vol. XLIV, No. 3, p. 169 (March, 1949).

Moon, Parry, and Spencer, D. E.: "Visual Performance and the Surround," *Journal of the Optical Society of America*, Vol. 38, 1948, p. 651.

"Luminous-Ceiling Lighting," (Not yet published).

"A Simple Criterion for Quality in Lighting," ILLUMINATING ENGINEERING, Vol. XLII, No. 3, p. 325 (March, 1947).

STORE interior at Kay Jewelry Co., Boston, Mass. Mobeco installation of cold cathode fluorescent lamps in recessed mirrored glass reflectors. Photo from Boston Edison Co., through Electric Institute of Boston.

Important Concepts Underlying Lighting for Critical Seeing

By MATTHEW LUCKIESH

KNOWLEDGE eventually simplifies complex subjects by providing the understanding which makes it possible to unravel them into major concepts, facts and principles. However, in the earlier stage of the evolution of knowledge of an inherently complex subject, there is often a period of increasing complexity before simplification takes place. Certainly at this stage we recognize that "the more we know, the more there is to know." This is commonly a period of confusion for the practitioner. Lighting practice appeared to be a relatively simple matter before its major principles and purposes were defined. Now with the introduction of appropriate concepts and relationships of light, vision and seeing, the specification of light and lighting is not a simple matter. Those who have been in a position to contribute to the unfolding of basic knowledge might also assume some responsibility toward simplifying the matter by isolating basic concepts, facts and principles. This is the purpose of this paper which the author believes fairly representative of advanced thought and knowledge.

To those engaged in basic research and analyses, the fundamental concepts upon which adequate lighting practices must be founded have been considerably clarified and extended in various directions in the past two or three decades. In general in the realms of critical seeing, the relatively inadequate foundation supplied by physical science has been underlaid by the science of seeing which also encompasses psychophysical and psychophysiological factors and effects. In other words, illuminating engineering in its relatively narrow sense is being more clearly recognized as a means to an end. It is an essential part of the physical chain which leads into the complexities of seeing and of seeing conditions. Such ends as human efficacy, efficiency, comfort and welfare, as properly extended concepts, are rising to the prominence they deserve.

The evolution of basic concepts and knowledge and the clarification of their importance in lighting and allied practices which affect seeing and seeing conditions is the result of many researches and analyses beyond the realms of the obvious. These researches have been extended along such major highways as visibility and ease of seeing and in many minor highways. A comprehensive review of all the scientific literature which has contributed to the evolution and clarification of basic concepts and knowledge is unnecessary for the present purpose. Therefore, the author felt that he could render a service by isolating and clarifying certain concepts which are so basic as to be beyond any serious doubt or disagreement. There may be honest differences of opinions pertaining to details, for the forefront of knowledge is no less controversial than the area of practice. There is always the possibility of differences of opinion in weighing the importance of various factors or effects. However, eventually basic concepts become clarified and they are added to the foundation underlying lighting practice. In this paper brief views are presented of important concepts and knowledge which appear to be soundly established in general, if not in detail.

A paper presented at the National Technical Conference of the Illuminating Engineering Society, Boston, Mass., September 20-24, 1948. Dr. LUCKIESH is Director of the Lighting Research Laboratory, General Electric Co., Cleveland, Ohio.

The Science of Seeing

Light and vision are *tools* for the performance of *seeing*. We may dig a ditch with a spade, but while doing so we are human digging-machines. Analogously, seeing is an activity of the human being operating as a human seeing-machine while using the essential tools of light and vision. In other words, the science of seeing is an extensive science which encompasses various specialized sciences of lesser scope. The science of vision in its most extensive sense does not encompass the entire activity of seeing and the effects of performing prolonged critical seeing. This is true of other possible sciences such as lighting or typography whose eventual purpose ends in the complex realm of seeing. The concept of seeing as a complex and the most universal voluntary and controllable human activity is an important evolution which has been greatly clarified and extended during recent decades. Already the science of seeing is a formidable structure of knowledge which may be likened to a house under construction. It is not complete but many structural details are giving it form and stability.

The science of seeing deals only incidentally, or at best only secondarily, with light. Strictly it is

confined to the visual sense which can be considered as a tool just as light is. This tool can be "sharpened" with eyeglasses if necessary, but it has inherent limitations just as any other tool; and these limitations are to some extent influenced by use and environment.

Eyesight specialists determine visual efficiency with specialized test-objects and test-charts which are adequate for their purpose but are not representative of most of the visual tasks in the world of seeing. They detect subnormal vision and when possible elevate it to so-called normal vision by means of eyeglasses. However, persons with normal vision, whether possessed without glasses or obtained by means of them, have, in effect, subnormal vision when performing many tasks of inherently low reflectance and low contrasts between critical details and their backgrounds under prevailing levels of illumination. Test-charts representative of such visual tasks and illuminated to the same level as these tasks of low reflectance and low contrasts, reveal low visual efficiencies which would be deplored by the eyesight specialist in his office. Nevertheless, these low visual efficiencies during the performance of such tasks are just as real whether existing *in effect* in the world of critical seeing or *in reality* in the office of the eyesight specialist. In countless tasks of this sort, light and lighting can contribute much after the eyesight specialist has taken care of the visual sense as a tool. By increasing the brightness-level of the task, the visibility-level is elevated and, in effect, the visual efficiency of those performing such tasks is increased.

The visibility of three-dimensional objects and critical details is influenced by the direction of the dominant component of light and by specular reflection. A skilled lighting specialist can increase visibility. In the last analysis, visibility and visual efficiency, as well as ease of seeing and seeing conditions, are influenced by certain fundamental facts and factors regardless of the manner in which the results are achieved.

Human Efficiency

The advent of the tungsten-filament lamp was practically coincident with the beginning of lighting practice as a specialized activity. This marked increase in the efficiency of light-production was quickly followed by further increases in the possibilities of artificial lighting when gas-filled tungsten lamps appeared. Soon World War I created a great demand for increased production on the industrial front and elsewhere. Naturally, this demand immediately appealed to the narrow materialistic view of lighting practice during that early period and much attention was given to the influence of footcandle-level upon the useful output of workers. Lighting and seeing conditions were so primitive that improvements in lighting resulted in increases in production and decreases in spoilage.

In the laboratory three decades ago, basic research was commonly confined to the realm of so-called physiological optics. Criteria for appraising the humanitarian value of more light and better lighting had as yet been given little attention. It was natural that the rate of performing useful work received a good deal of attention, but this criterion was destined to be examined critically with the result that its limitations were revealed. Many experiments involving the influence of footcandle-level upon the rate of producing useful work indicated that the optimum rate was commonly attained at 10 or 20 footcandles for various kinds of work that required the guidance of vision. Where seeing greatly predominated over manual activity, the optimum rate was attained at somewhat higher footcandle-levels. However, this concept took little or no account of the cost in human resources.

Eventually, more penetrating examination of such a task as reading, for example, indicated that other factors, such as reaction-times, reading habits and comprehension limited the rate of reading. It was also found that two tasks, differing greatly in ease of seeing, could be performed at nearly the same rate. An interesting example of that early period of basic research involved reading the same material when vibrating and when stationary. Notwithstanding the fact that there was overwhelming evidence that reading the vibrating printed material was a far more severe task than reading the same material when stationary, there was little difference in the rate of reading. Thus the limitations of rate of production as a criterion of lighting and seeing conditions were revealed. Inevitably, advances in thought and knowledge were destined to expand the concept of efficiency of a worker.

Eventually the concept of seeing as an activity of the human being operating as a human seeing-machine became clarified. The amount of useful work performed by a worker per hour—or per dollar—could no longer be accepted as an adequate criterion. This may measure his efficiency from the viewpoint of his employer or of narrow monetary economics. However, the concept of the overall efficiency of a worker engaged in the activity of seeing was naturally expanded to that commonly applied to any machine. Thus the efficiency of the worker was theoretically defined as the ratio of the *useful* work done to the *total*.

In an ordinary device such as an electric motor or transformer, the useful work is obvious. The useless work is less obvious for it is represented by friction and internal losses. The human seeing-

machine performs obvious useful work, but there is a waste of human resources in useless work. This extended concept has stimulated search for unobvious hidden physiological or psychophysiological effects of performing prolonged critical seeing. Some effects have been revealed, but much research is still needed in this rather new realm. However, this extended concept is no longer merely theoretical. It is the proper humanitarian concept of the overall efficiency of anyone engaged in critical seeing.

Many installations in the neighborhood of 50 footcandles were made in industry and elsewhere during World War II. These are footcandle-levels above those at which the rate of production appeared to be practically maximal in earlier investigations dealing with a rather narrow concept of the purpose of lighting. Such installations are actual proof that in practice the extended concept of the efficiency of the worker is gaining recognition. The humanitarian objective of conserving human resources is a primary factor in the design and acceptance of higher levels of illumination. Furthermore, the basic concept is not confined to the conservation of human resources during a day, but during a lifetime of work.

Visibility and Ease of Seeing

As basic research and analysis progressed, it became clear that every seeing task could be considered from two broad viewpoints. When our attention is predominantly focused upon the visual task, the *visibility* of critical details is all-important. However, when we consider the performance of that task by human beings for a prolonged period of time, *ease of seeing* should also receive attention. These two viewpoints can be considered separately, but they are not inseparable in the actual performance of prolonged critical seeing. It appears axiomatic that when visibility is low, prolonged seeing results in greater waste of human resources than when visibility is high. In basic research these have been studied separately and some progress has been made toward correlating them.

It is still a mystery to the author why, in a civilization largely built by and for visibility, the problems of defining visibility and of establishing units and means of measuring visibility were so long and so generally postponed. Through research and analysis it has become apparent that the only definite visibility-level is that of threshold visibility. However, no one is completely satisfied to be able *to barely see*. In practice, visual tasks by some controllable means are elevated—or can be elevated—into the realm of supra-threshold visibility. Excepting when critical details are such that they are beyond the limits of the visual sense, their visibility can be raised to various supra-threshold visibility-levels by increasing the footcandle-level. Other factors such as direction of light, specular reflection and preventable glare also affect the visibility-level.

Inasmuch as the only visibility-level that we can detect with our visual sense is the threshold-level, the supra-threshold visibility-level of a visual object or task under a given condition is determined by what must be done to reduce the object or task to threshold visibility. This can be accomplished by altering one or more of the four fundamental factors such as size of the critical details, contrast with their background, brightness-level, and time available for seeing. Research and development have yielded meters, units and scales of visibility and advances have been made in determining visibility-levels and in the relationships of footcandle-level and other factors to supra-threshold visibility. The principle involved is that if the visibility-levels of two objects or tasks are equal to the visibility-level of a standard object under standardized conditions, the visibility-levels of the two objects or tasks are at least approximately equal. The concepts and knowledge in this realm are adding to the development of a science of lighting which must supply sound specifications of light and lighting.

One of the important correlations that probably will be made eventually is that relating visibility-level and ease of seeing. Visibility-level can be determined rather easily, but as yet there is no single practicable criterion of ease of seeing that can be applied quickly. The latter is the combined result of all the psychophysiological effects resulting from the performance of prolonged critical seeing. Up to the present time researches in this realm have dealt with determinations of fatigue of the extrinsic muscles of the eye and of the ciliary muscle, of nervous muscular tension or tenseness manifested in some measureable manner, of the heart-rate, of the rate of involuntary blinking, of general bodily and mental fatigue, etc. Such researches already have established the appropriateness of the concept of seeing as an activity of the human being which involves muscles and organs and also general effects such as muscular, neural and mental fatigue. As these realms are very complex and have only recently been invaded, the picture is far from complete; in fact, there are still being discovered the influences of various other external factors which must be correlated.

The physician measures blood pressure not only for itself but for the knowledge it reveals of more deeply hidden and less easily measured factors or effects. Likewise, the seeing specialist can readily measure visibility-level and provide light and light-

ing to raise the visual object or task to a reasonable or desirable visibility-level. As knowledge progresses, measurements of visibility-level will probably be correlated more and more with the degree of ease of seeing. In the meantime, the determination of visibility-levels and the specification of footcandle-levels on this basis provide a greatly improved foundation for scientific lighting practice and automatically influence ease of seeing. Understanding, experience and common sense in the use of this technique are important, as they are to the physician, for example, who measures blood pressure to guide his diagnosis and practice.

Brightness-Level

Brightness has long been recognized as a basic factor in scientific studies of the visual sense or what has been termed, physiologic optics. However, until recently it has been an unduly neglected concept in illuminating engineering. The level of illumination in cooperation with the diffuse reflectance of a surface produces the brightness-level. The brightness-level of a visual task is a very important influence upon the visibility-level of the task. Footcandle-level is meaningless in this respect unless the diffuse reflectance of the task is taken into account. Brightness-ratios between the task and its immediate surroundings and elsewhere in the visual field are important factors in brightness engineering.

One need only examine the specifications of footcandles in the lighting codes of the past to learn that the concept of brightness-level of the task was either entirely or almost entirely absent. Such recommendations as 10 footcandles for sewing on light goods and 20 footcandles for sewing on dark goods reveal an almost total lack of appreciation of the importance of brightness-level and of the limitations of footcandle-levels in general. Actually, 10 footcandles on a diffusely reflecting "white" surface, having a reflectance of 80 per cent, produce the same brightness-level as 100 footcandles produce on a dark gray textile having a reflectance of 8 per cent. The same black details will still be at a lower visibility-level on the dark gray background than on the white background owing to the lower brightness-contrast of black on dark gray than black on white. These two tasks illustrate those in an office or in a garment factory. Certainly the ideal objective is to give the workers in such a factory (sewing with black thread on dark textiles) the same benefits from light as their co-workers in the office of the factory. This is not accomplished only by having the respective tasks at the same brightness-level, but this represents a large step in the right direction. A further desirable step is to provide footcandle-levels to elevate the respective tasks to the same visibility level.

Can anyone deny that these factory workers have just as much right to be benefited as much by light as the office workers? This may not be "practicable" in many cases at the present time, but it is a proper concept, and much more can be done for those performing tasks of inherently low visibility than is being done at the present time. Certainly one of the major objectives of a science of lighting is to specify footcandles to fit the task just as motors are specified for tasks of different requirements. With an adequate concept of the basic importance of brightness-level, recommendations of footcandle-levels would have been far better fitted to the respective tasks in codes of lighting practice. Only recently has this concept begun to wield an influence comparable to its basic importance. In a more refined sense, footcandles should be specified to fit the visual sense involved as well as the task. For the present, it may generally suffice to note that average vision of a group of persons is generally subnormal vision due to the fact that persons with subnormal vision are generally present.

Footcandle-Levels

The level of illumination at which an object is barely visible or at which a visual task, such as reading this page of printed matter, can barely be performed can be readily determined and demonstrated. This is the threshold footcandle-level for a given case and it is neither desirable nor acceptable for prolonged seeing from any viewpoint. The ideal footcandle-level from the viewpoint of maximum ease of seeing is that at which the waste of human resources is minimized. In other words, the ideal footcandle-level is that at which the overall efficiency of the human seeing-machine is a maximum. Obviously, it is desirable that all the psychophysiological effects resulting from the performance of prolonged critical seeing be taken into account.

Perhaps eventually from researches in the realm of effects of seeing, a simple practical criterion will evolve and some degree of correlation between visibility-level and ideal brightness-level appears possible. At the present time the ideal brightness-level from the viewpoint of minimizing undesirable physiological and psychophysiological effects of seeing appears to be above 100 footlamberts. There are some indications, including our knowledge of the sensitivity of the visual sense, that it may be about 400 footlamberts, which is of the order of the brightness-level of a green grass lawn at noon on a clear day in summer.

Recommended footcandle-levels are always compromises unless they are ideal footcandle-levels which result in maximum ease of seeing. No basic researches can establish such compromises. How-

ever, it is possible and practicable to choose a reasonable visibility-level and to specify footcandle-levels necessary to elevate various visual tasks, respectively, to this visibility-level. At least such a procedure fits footcandles to the respective tasks. It readily reveals a great range of footcandle-levels, only a portion of which is represented by specifications in even the latest codes of lighting practice.

Brightness Engineering

The importance of brightness is being extended in detail to the entire visual field. High brightness-contrasts are desirable between the critical details of a visual task and their surroundings or backgrounds. With this exception, brightness-ratios should generally be reduced to reasonably low values everywhere in the visual field. It has been adequately proved by various researches that the surroundings of a visual task, such as this printed page, should be of a brightness-level comparable to the task. This entire aspect of seeing conditions is still a complexity which has not been completely unraveled, but it has been adequately proved that low brightness-ratios are generally desirable in the visual field wherever critical seeing is not involved.

In practice one often reads a book, for example, when it is a hundred times as bright as its surroundings which may be a carpet of very low reflectance and whose level of illumination is much less than the printed page. This may be described as a very poor seeing condition. Insofar as a glare-source is an undesirable distraction which causes an undesirable seeing condition, the dark surroundings of a task are also a "glaring" distraction.

A light-source or lighting fixture is more glaring when its background is relatively dark than when relatively bright. High brightness-ratios of this character in the visual field are undesirable for they are major causes of poor seeing conditions. Lighting and seeing conditions are improved by minimizing these brightness-ratios, and in practice these are accomplished by shielding the light-source and using translucent media. Overall it is also accomplished by the cooperation of light and the reflectances of various areas.

Another brightness-ratio of importance, owing to its effect upon ease of seeing and upon seeing conditions, is the brightness-level of the visual task compared with that of the ceiling or of any other area of comparable visual size in the visual field. These brightness-levels should be comparable. The brightness of a large expanse of ceiling, for example, should not be several times brighter than the visual task as is true of indirect lighting. If in such cases of general lighting, glareless localized or directed light is added to the task to elevate its brightness-level to, or even somewhat above, that of the expanse of ceiling such matters as the visibility of the task, ease of seeing and seeing conditions will be improved. This is generally as demonstrable as the effect of glaring light sources in the visual field which have received much attention. Actually, the task should generally be of a brightness-level comparable with that of any area of comparable visual size anywhere in the visual field. The undesirable effect of brightness generally diminishes with its angular distance from the line of vision.

Space is not available for a detailed discussion of the various factors involved in brightness engineering. Much experimental work is still necessary to produce a generally acceptable correlation of them. The desirable limits of these various brightness-ratios are known only approximately, but there is sufficient knowledge for the practice of reasonably satisfactory brightness engineering toward easier seeing and better seeing conditions. In considering the brightness of various areas in the visual field and the brightness-ratios of adjacent areas, it is helpful to think of the eyes as operating in a dual capacity. They are optical devices which focus images of visual objects on the retinae whence they reach the realm of perception. They may also be considered to be corridors through which impressions of the entire scene eventually reach the realms of association, feeling, sentiment and esthetic satisfaction. Therefore, even seeing conditions, which involve the effects of factors in the entire visual field, may have to be compromises in order to be reasonably satisfactory in both utilitarian and psychological senses. Human beings are more than seeing-machines. They are *human* seeing-machines.

Opportunity and Responsibility

Many minor factors and combinations enter into the various problems and environments of seeing. Lighting practice will profit and progress in proportion to the application of the basic concepts and knowledge which are available.

In the development of basic concepts and knowledge, high noon is in sight. Lighting specialists, and others who would become seeing specialists, have been greatly enriched by a variety of new light sources and great advances in the efficiency of light-production and efficacy of light-control. If they will apply these tools with adequate comprehension of basic concepts and utilization of the knowledge already available and evolving, marked advances toward the zenith of lighting practice will be achieved. The opportunities are great and they are only equaled by the responsibilities which deal universally with human efficiency, comfort, welfare and happiness.

Lighting a Kitchen Laundry

LIGHTING OBJECTIVE: To provide illumination of such design as to meet current good lighting practice and to produce the desirable effects using the new light sources.

Installation at Horizon House, Lighting Institute, General Electric Company, Nela Park, Cleveland, Ohio.

General Information: Within a space of 12 ft. 6 in. by 10 ft. (ceiling height 8 ft. 6 in.), a kitchen-laundry has been installed. The ceiling is in scalloped awning stripes of green and white with a band of geranium red directly below the scallops. The green, chosen for its color quality when viewed under fluorescent lamps, is of 70 per cent reflectance; the white, 74 per cent; and porcelain equipment, 80 per cent. At the time of construction the only suitable linoleum available was dark, mottled blue-green and a narrow trim divider strip of the geranium red was used. (However, a lighter color is recommended for work counters and floor covering.) The equipment is standard stock with the exception of the custom-built, drop-leaf table hinged to laundry wall to provide additional counter space.

Figure 1. Left. South wall. **Figure 2. Below. North wall**

Installation: General lighting is provided by one central ceiling fixture having plastic side and end-shields with metal louvered bottom. This unit (manufactured by John C. Virden Co., Cleveland, Ohio; Catalog No. VS-524) employs two 40-watt fluorescent lamps. For greater efficiency the fixture is attached to a white board, superimposed on the ceiling, extending 6 in. beyond the unit dimensions.

The white enamel under-cabinet units (manufactured by the Art Metal Co., Cleveland, Ohio; Catalog No. 2993) shield the lamps from view at ordinary working positions and employ one 20-watt fluorescent lamp. The supplementary range lighting is provided by one 40-watt fluorescent lamp in an adjustable reflector type unit (Moe-Bridges Corp., Sheboygan, Wisconsin; Catalog No. FL-31/48. The over-sink soffit uses two 40-watt fluorescent lamps, each with a polished reflector mounted in a cavity 11 in. square by 49 in. long. The bottom glass cover-plate is of Blue-Ridge "Louvrex," fire polished, and manufactured by Libby-Owens Ford Co., Toledo, Ohio. Reflectors are manufactured by the Wiremold Co., Hartford, Conn. Center portion of laundry is illuminated by a 64-inch slimline lamp mounted on under side of center cabinets (ballast located in upper part of adjacent cabinet). All lamps used are 3500°K white fluorescent.

Average general illumination levels based on four readings, each taken in center of quadrant 30 in. above floor are as follows: center fixture only, 12.2 ft-c; local lighting only, 13.8 ft-c; entire kitchen lighting on, 25.5 ft-c. The center fixture supplies from 5 ft-c at the lowest point along the work surface (north wall) to 12 ft-c at the highest point, the kitchen sink. The latter value is reduced as much as 10 ft-c due to a shadow produced by individual at work. The work lights under the cabinets com-

(over)

A.I.A. File No. 31 f 12

bined with the soffit over the sink provide from 50 to 65 ft-c along the corresponding surfaces. The local lighting along the laundry side (south wall) ranges from 20 to 45 ft-c. The combined effect of center fixture and work lights supplies over 40 ft-c excepting for two points. Table II indicates the reduction due to shadow cast by individual at work. Representative brightness values are shown in Table III.

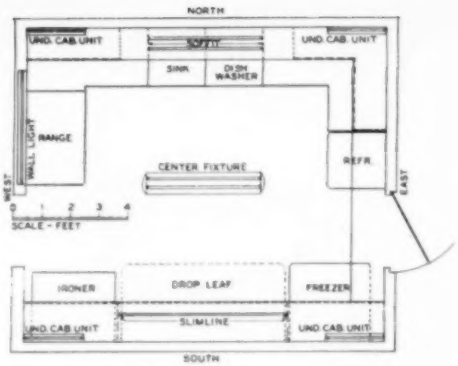


TABLE I—Lighting Load

Unit	No. of Lamps	Type	Total Watts
Ceiling fixture	2	all lamps 3500°K white general line fluorescent	108
Under cabinet units	4	" " "	98
Supplementary range unit	1	" " "	49.5
Soffit over sink	2	" " "	108
Under cabinet—over drop leaf	1	slimline—200 milliampere	54
Total number of lamps	10	Total number of watts	417.5

TABLE II—Footcandle Values for Specific Visual Tasks

All readings were taken through the center of the work surfaces reading from left to right when facing the wall area indicated. Height of work surface, 39 inches.

	North Wall								South Wall									West Wall		
	Left-Hand Work Counter			Center Sink	Dish Washer Center	Right-Hand Work Counter			Home Freezer			Drop Leaf			Ironer			Top of Range		
Location	3"	24"	43"	60"	84"	98"	120"	141"	10"	22½"	35"	50"	75"	100"	115"	127½"	140"	3"	19½"	36"
General Lighting																				
Center fixture	4.5	7.	10.5	12.	11.	9.	5.7	3.	4.5	6.	8.	10.	18.5	12.5	10.	8.	6.5	11.5	10.5	8.5
Center fixture, person at working position	2.5	2.	4.5	2.5	4.5	5.	2.	1.	1.5	2.5	2.5	3.	3.5	3.	2.	2.	2.2	3.5	3.5	3.
Local Lighting																				
Under cabinet units only	51.5	29.	3.	5	1.	3.	26.	49.	44.	37.5	10.	2.5	2.	2.5	7.5	30.5	38.			
Soffit over sink only	1.	20.	49.	65.	63.	47.	16.	1.												
Under cabinet units and soffit	52.5	49.	52.	65.5	64.	50.	42.	50.												
Slimline only									1.3	3.5	12.5	26.5	39.	27.5	12.5	4.	1.3			
Under cabinet units and slimline									45.3	41.	22.5	29.	41.	30.	20.	34.5	39.3			
Supplementary range fixture																		32.	56.	36.
Entire Kitchen Lighting On																				
All units lighted	86.	60.	68.	82.	80.	62.	48.	54.	60.	58.	34.	42.	56.	44.	33.	41.	45.	48.	74.	68.
All units lighted, person at working position	82.	54.	62.	74.	71.	58.	44.	52.	57.	44.	28.	47.	50.	38.	25.	33.	39.	44.	70.	62.

TABLE III—Brightnesses in Footlamberts on Upper Wall Surfaces

An average of five readings taken on each of the three sets of cabinets positioned as indicated.

	South Wall Cabinet Fronts			West Wall
Location	Above Home Freezer	Above Drop Leaf	Above Ironer	Wall Surface Above Range
Center fixture	43.5	110.	64.	52.5
All units lighted	72.	148.	97.5	89.5

Note the increase in wall brightness when local lights are added to the center general light.

Installation designed by E. W. Commery; architecture designed by M. L. Gormley.

Lighting data submitted by E. W. Commery, Engineering Division, Lamp Department, General Electric Company, Nela Park, Cleveland, Ohio, as an illustration of good lighting practice and to aid in the design of similar installations.

Distributed by the Committee on Publications of the Illuminating Engineering Society, 51 Madison Ave., New York 10, N. Y.

Engineering Aspects of Cove Lighting Design

By LORIN C. BROWN
J. R. JONES

Certain elements in the design of coves utilizing fluorescent lamps are investigated, and their effects on backwall and ceiling brightness patterns, illumination levels, and overall efficiency are recorded. Attention is called to some of the interrelationships existing among these factors. Coefficient of utilization tables for various mounting heights are given.

A SURVEY of the existing literature on cove lighting design reveals comparatively little in the way of detailed technical data. Particularly is this true with regard to information adaptable to the prediction of backwall and ceiling brightnesses. Since the use of coves in many modern installations indicates a need for such data, several aspects of cove design have been investigated.

The primary purpose of a cove may be the production of illumination, or the creation of a decorative effect. In either case a successful installation must provide a pleasing brightness pattern, which is seldom attained as the result of chance. Tests have been made on the variations in brightness and illumination levels which result from altering certain dimensions and physical features of the cove. The data assembled and conclusions drawn from these tests are offered for assistance in estimating the results to be expected from either a utilitarian or a decorative installation. The creation of the aesthetic effect is left to the designer or architect.

Test Facilities

A special test room, 12 feet by 20 feet with a 10-foot 4-inch ceiling, was constructed. A single 12-foot cove was installed across one side of the room. Although in actual practice coves are usually located symmetrically on all four or on two opposite sides of a room, it was believed that data for a single cove would be most helpful. Illumination and ceiling brightness values for more than one cove can readily be obtained by additive means, whereas data for a two-cove installation cannot be separated into the components contributed by each cove, and hence are of no value for rooms of other dimensions. Provision was made for easily altering cove proportions, mounting height and room size. Curved sections were also constructed for location above the cove to provide a continuous reflecting surface from wall to ceiling.

The ceiling of the room was painted flat white, with a reflectance of approximately 85 per cent, and the walls pale green of approximately 65 per cent reflectance. On the end wall where the cove was located, the white paint was carried down two feet from the ceiling to provide a white backwall between the ceiling and the cove, the inner surface of which was also painted white. The reflectance of the floor was about 10 per cent. Brown paper with a 34 per cent reflection factor was used to cover the walls for certain of the tests.

The lighting equipment used for the tests consisted of 30-watt, 40-watt, 100-watt and slimline white fluorescent lamps, mounted on commercially available wiring channel. The channel was painted white and equipped with removable specular Alzak aluminum reflectors. Each lamp was keyed to the lead or lag side of a specific ballast, and, after seasoning, was read for lumen output at the current provided by that side of that ballast when operated at rated voltage. All lamps were then used throughout the tests in their keyed ballast positions, and

A paper presented at the National Technical Conference of the Illuminating Engineering Society, Boston, Mass., September 20-24, 1948. Mr. Brown and Mr. Jones are with the Commercial Engineering Department, Westinghouse Electric Corp., Bloomfield, N. J.

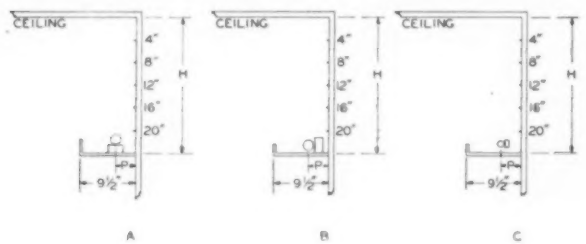
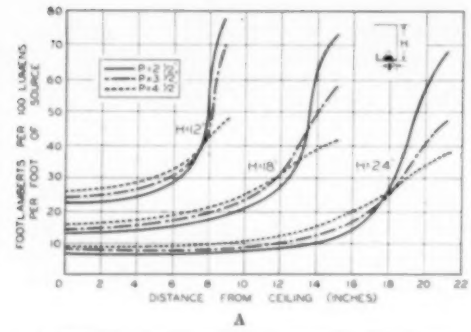
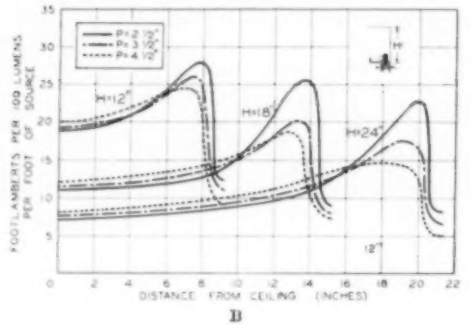


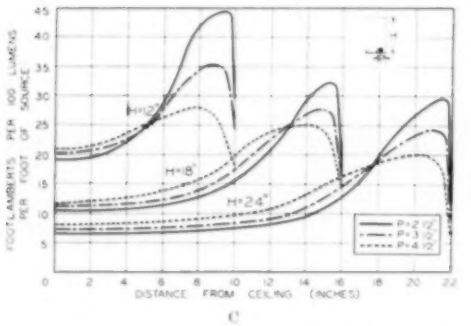
Figure 1. Three methods of lamp mounting employed in study of lamp placement. Distance of cove below ceiling is designated by *H*, distance of lamp center from wall by *P*. (A)—T-12 lamp over 2¼" x 1⅞" channel. (B)—T-12 lamp in front of same channel as in (A) (C)—T-8 lamp in front of 1¼" x ⅞" channel.



A



B



C

Figure 2(A). Top. Backwall brightness vs. distance from ceiling for various *H* and *P* relationships, with T-12 lamps located as in Figure 1(A). Readings adjusted to 100 lumens per foot of source. Reflection factor of backwall, inner surface of cove, and ceiling 85%; walls 65%. Measurements made at the center of a 12-foot cove.

Figure 2(B). Center. As 2(A), except T-12 lamps located as in Figure 1(B). Sharp drop at righthand end of curves represents shadow caused by corner of channel.

Figure 2(C). Bottom. As 2(A), except T-8 lamps located as in Figure 1(C). Sharp drop at righthand end of curves represents shadow caused by corner of channel.

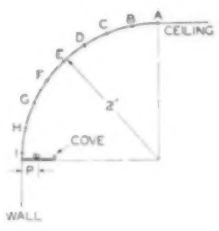
the primary voltage was maintained at the rated value (118 volts).

With these facilities, a study was made of a number of test installations involving certain variations in cove shape, distance from the ceiling, lamp position, number of rows of lamps, use of reflectors, and wall reflection factor. A Luckiesh-Taylor brightness meter was used to measure wall and ceiling brightnesses. Illumination measurements were made with a color-corrected multi-cell meter, equipped with a diffusing cover designed to minimize errors resulting from large percentages of light striking the cell surface at oblique angles.

Lamp Placement

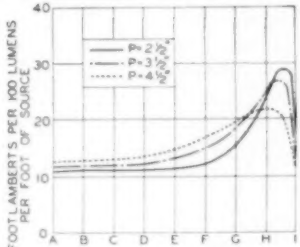
One of the important factors in the appearance of a cove lighting installation is the brightness distribution on the immediately adjacent wall and ceiling surfaces. To investigate the effect of lamp position on wall brightness, a test set-up was made with a simple rectangular cove 9½ inches wide, mounted against a flat backwall. Backwall brightnesses were then measured with bare T-12 lamps over a $2^{3}/_{4}$ inch by $1^{7}/_{8}$ inch channel, as illustrated in Fig. 1(A), and also with the lamps in front of the channel, as in Fig. 1(B). T-8 lamps were mounted in front of a smaller channel, $1^{1}/_{4}$ by $^{7}/_{8}$-inch—Fig. 1(C). The distance of the cove from the ceiling *H* and the distance of the lamp center from the wall *P* were varied through three different values for each of these mounting arrangements. The top of the cove lip was made even with the lamp center in each case. Brightness readings were taken every two inches down the backwall from the ceiling, at the center of the cove. The results of these measurements, corrected to 100 lumens per foot of light-source length, are presented graphically in Fig. 2.

Figure 3. Below. Brightness of curved backwall section of two-foot radius for three *P* distances, with T-8 lamps located at shown. Readings adjusted to 100 lumens per foot of source. Reflection factor of curved backwall 75%, ceiling and inner surface of cove, 85%, walls 65%. Drop at righthand end of curves represents shadow caused by corner of channel.



CURVED SECTION

A



POINTS ON SECTION

B

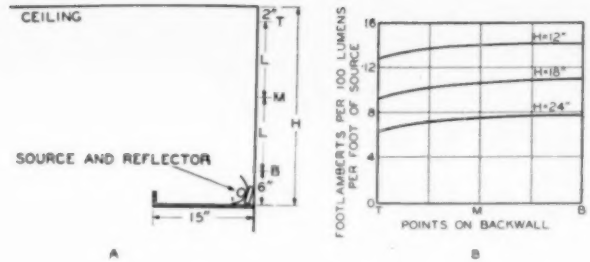


Figure 4. Backwall brightness for three *H* values, with T-12 lamps in 5-inch concentrating reflectors located as shown. Axis of reflector tilted at angle of approximately 20°. Measurements made at 2" from ceiling, 6" from floor of cove, and halfway between, in the center of a 12-foot section. Readings adjusted to 100 lumens per foot of light source. Reflection factor of backwall and ceiling, and inner surface of cove, 85%; walls, 65%.

From a comparison of Figs. 2(A), 2(B) and 2(C) it is obvious that more uniform brightness can be obtained when the lamps are mounted in front of the channel, as in Figs. 1(B) and 1(C), than over the channel, as in 1(A). It is also evident that the higher values of *P* (distance of lamps from wall) are more desirable from this standpoint, although they necessitate wider coves which may create complications in construction or appearance. The minimum desirable *P* distance is largely determined by *H*, since when the cove is near the ceiling multiple interreflections between the inner surfaces of the cove, the backwall, and the ceiling tend to reduce the vertical brightness variation over the surface of the backwall. At greater values of *H* the effect of the interreflections is much less marked. The eighteen test set-ups represented by the curves in Figs. 2(B) and 2(C), judged on the basis of appearance, indicated that for an *H* value of 12 inches any of the three *P* values used was satisfactory. For *H* equals 18 inches, a *P* value of either $3\frac{1}{2}$ inches or $4\frac{1}{2}$ inches produced a reasonably good appearance, whereas for *H* equals 24 inches only the results obtained with a *P* value of $4\frac{1}{2}$ inches were pleasing.

The effect of *P* was also investigated for a cove with a curved backwall section of 2-foot radius, with bare T-8 lamps mounted in front of a $1\frac{1}{4}$-inch by $\frac{7}{8}$-inch channel as shown in Fig. 3(A). Brightness measurements were taken, for several values of *P*, at 4-inch intervals around the curved surface. Data for three *P* distances are plotted in Fig. 3(B). The results obtained do not differ greatly from those for straight backwalls at corresponding *P* distances. Again a *P* value of $4\frac{1}{2}$ inches for $H = 24$ inches produces a reasonably uniform backwall brightness. The shadow indicated by the drop at the right end of the curve is almost imperceptible.

Table 1.—Minimum Lamp-to-Wall Distance for Satisfactory Freedom from Scallops*

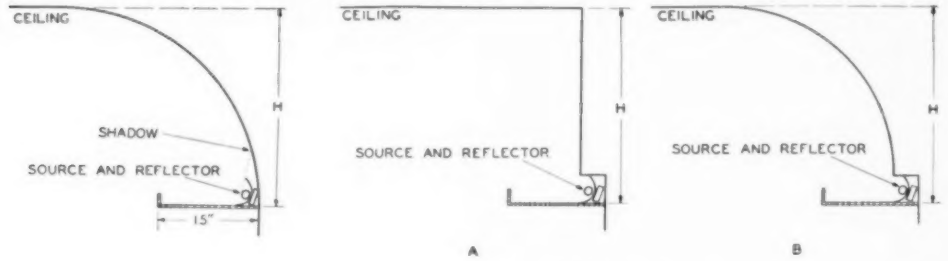
	H = 12"	H = 18"	H = 24"
Lamps Over Channel.....	$P = 5$"	$P = 6$"	$P = 7$"
Lamps in Front of Channel	$P = 2\frac{1}{2}$"	$P = 3\frac{1}{2}$"	$P = 4\frac{1}{2}$"

*30-watt T-8 and 40-watt T-12 lamps in standard lampholders mounted back to back; white ceiling, backwall and cove interior.

Although "scallops," or dark spots on the backwall above the lampholders, are sometimes part of the decorative scheme, in general they are undesirable. The extent of the dark spots and their contrast with the brighter areas obviously depends upon the distance between the luminous portions of adjacent lamps, and upon the distance of the lamps from the wall, as well as upon the method of lamp mounting. Both test readings and observations proved that the *H* and the reflectance of ceiling, backwall and cove interior are important factors, since interreflections between these surfaces reduce scalloping effect as well as vertical backwall brightness variation. When measurements were made on 30-watt T-8 and 40-watt T-12 lamps mounted in standard lampholders placed back to back, it was found that *P* values in accordance with Table I were necessary to reduce the scalloping

Figure 5. Test set-up with curved backwall section of 2-foot radius, T-12 lamps in 5-inch concentrating reflectors.

Figure 6. Cove constructions employing recessed reflectors. (A)—Straight backwall. (B)—Curved backwall section.



effect sufficiently for a reasonable appearance.

If the lamps are located over the channel, scallops may be eliminated or reduced either by overlapping the lamps or by using an additional row of lamps in a staggered position. Where the length of the lampholders or the construction of the lamp itself is such that the luminous ends of the source are separated by much more than $1\frac{1}{2}$ inches, some correction of this type is necessary.

Use of Reflectors

Another subject of investigation was the effect of adding reflectors to the bare lamp installations described in the previous section. The reflectors chosen for the T-12 lamps were of the concentrating type, five inches wide. Fig. 4(B) shows the results of backwall brightness measurements on an installation such as is diagrammed in Fig. 4(A), with the channel placed against the wall and the axis of the reflector inclined at an angle of approximately 20° above the horizontal. The measurements showed such a high degree of brightness uniformity that obviously there was nothing to be gained by moving the channel away from the wall. For this type of installation it is possible through the use of reflectors to obtain a uniform backwall brightness with complete freedom from scallops.

The same type of reflector was also tested in an installation with a curved backwall section (Fig. 5). Here the reflector caused a very sharp shadow at the point indicated in the drawing. This shadow is more conspicuous because the curved wall is very close to the reflector, and also because the light strikes the surface at a smaller angle of incidence than is the case with the straight backwall. Any change in the position of the reflector to soften the shadow results in greater absorption of light by the lip of the cove. Since it seemed that the existence of the shadow would preclude the use of reflectors in such an installation, no further measurements were made.

Two types of construction employing recessed reflectors are illustrated in Fig. 6. In these installations direct light from the source falls only on that portion of the ceiling which is at some distance from the cove. The backwall and immediately adjacent ceiling area are illuminated by means of light reflected from the lip of the cove. This type of cove has been largely used with filament lamps, because it greatly facilitates the production of uniform backwall and ceiling brightness when concentrated sources are used. With extended sources such as fluorescent lamps, it is seldom necessary to resort to recessed construction to achieve satisfactory uniformity. In this latter type of installation, a higher level of brightness is created on the more distant areas of the ceiling if the reflector is of specular finish, and parabolic in shape. Regardless of the nature of the source, best results are obtained when the floor and lip of the cove are highly diffusing and highly reflecting.

A study of Figs. 8 and 10, giving ceiling brightness and illumination data for the installation of Fig. 4(A), and Figs. 7 and 9, giving comparable data on similar installations without reflectors, shows that both the brightness and illumination curves are displaced somewhat toward the center of the room by the addition of reflectors. Since ceiling brightness is determined by both direct light from the source and reflected light from the room surfaces, the effectiveness of reflectors depends very largely upon the dimensions of the room and the reflectances of walls, ceiling, and floor. The larger the room and the lower the reflec-

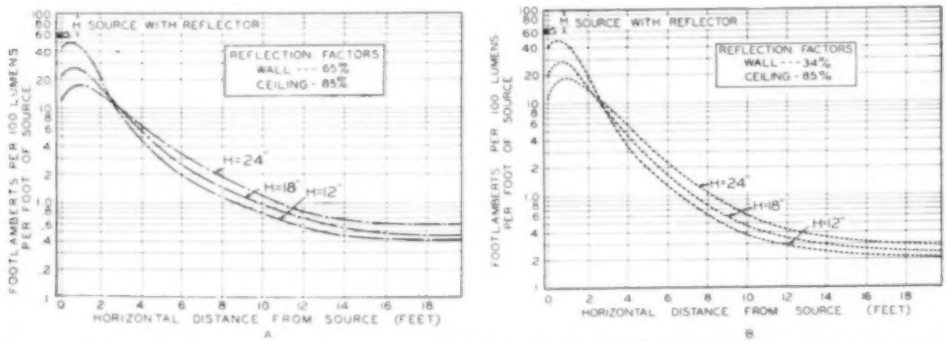


Figure 7. Ceiling brightness for three H values, T-12 lamps located as in Figure 1(B). For $H = 12''$, $P = 2\frac{1}{2}''$; for $H = 18''$, $P = 3\frac{1}{2}''$; for $H = 24''$, $P = 4\frac{1}{2}''$. Readings adjusted to 100 lumens per foot of light source. Measurements made at the center of a 12-foot cove section, at one-foot intervals starting from the center of the lamp along a line perpendicular to the axis of the cove. Reflection factor of ceiling, backwall, and inner surface of cove 85%. (A) Reflection factor of walls 65%. (B)—Reflection factor of walls 34%.

tances, the greater the effect of the reflectors. A comparison of Figs. 7(A) and 8(A) for a 65 per cent wall reflection factor, indicates that the reflectors cause little difference in ceiling brightness toward the opposite side of the room. The corresponding curves for a 34 per cent wall reflectance—Figs. 7(B) and 8(B)—show an increase of about 25 per cent in ceiling brightness toward the far end of the room by the use of reflectors. Comparable tests proved that in a large space with very low wall reflectance the use of reflectors approximately doubled the ceiling brightness at some distance from the cove.

One disadvantage inherent in the use of reflectors is that they require greater shielding and cove width to conceal the larger source from view. Smaller reflectors are more desirable from this standpoint, but the reflector must be reasonably large with respect to the lamp to prevent an actual loss in efficiency. Two-inch reflectors with T-8 lamps, although they produced an attractive brightness pattern, were less efficient than the bare lamps.

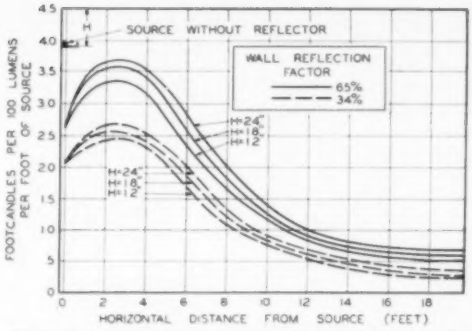


Figure 9. Footcandles on the working plane for three *H* values and two wall reflectances, T-12 lamps located as in Figure 1(B). For $H = 12''$, $P = 2\frac{1}{2}''$; for $H = 18''$, $P = 3\frac{1}{2}''$; for $H = 24''$, $P = 4\frac{1}{2}''$. Readings adjusted to 100 lumens per foot of light source. Measurements made at the center of a 12-foot cove section, at one-foot intervals starting from the center of the lamp along a line perpendicular to the axis of the cove. Reflection factor of ceiling, backwall, and inner surface of cove 85%.

Cove Proportions

Cove proportions and lamp placement are closely interrelated, and some consideration has already been given to the subject of cove proportions in the discussion of lamp placement. As demonstrated by the tests reported in Fig. 2, for bare lamp installations the dimension *P* (distance of lamp from wall) is an important factor in determining the brightness pattern on the backwall. However, when measurements of ceiling brightness and foot-candle levels were made, the value of *P* was found to have little effect on the results. Thus in studying the influence of cove proportions on ceiling brightness and illumination, *H* (distance from cove to ceiling) was the principal variable to be considered. Lamps were mounted in front of the channel, as in Fig. 1(B), and the *P* value for each of the bare lamp set-ups was chosen in accordance with what had already been determined to be desirable from the standpoint of backwall brightness uniformity and reasonable freedom from scallops. Where reflectors were used the channel was placed against the wall and aimed 20° above the horizontal.

Figs. 7 and 8 show the results of ceiling brightness measurements on set-ups with and without reflectors, for three different values of *H* and two different wall reflection factors. Readings were taken at one-foot intervals along a line through the center of the room and perpendicular to the axis of the cove. The range over which the readings

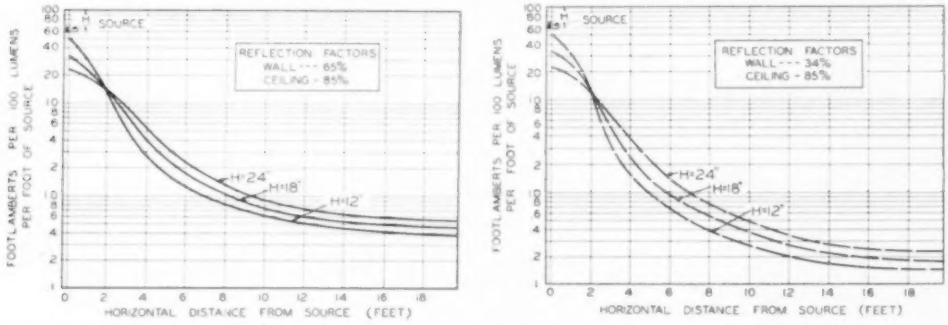


Figure 8. Ceiling brightness for three *H* values, T-12 lamps in 5-inch concentrating reflectors located as shown in Figure 4(A). Readings adjusted to 100 lumens per foot of light source. Measurements made at the center of a 12-foot cove section, at one-foot intervals starting from the center of the lamp along a line perpendicular to the axis of the cove. Reflection factor of ceiling, backwall, and inner surface of cove 85%. (A)—Reflection factor of walls 65%. (B)—Reflection factor of walls 34%.

extended made it desirable to use a logarithmic scale in plotting the results.

Measurements of illumination on the working plane were made for these same installations, and the results are presented in Figs. 9 and 10. Readings were again taken at one-foot intervals along a line normal to the axis of the cove and passing through the center of the room. Since in a cove lighting installation the ceiling and backwall become the source, so their average brightness determines the average illumination level. The brightness of the backwall and ceiling near the cove are produced by direct light from the source and by interreflections between the inner surface of the cove, backwall, and ceiling. The ultimate value is determined largely by the reflectance of these surfaces and by the distance *H*. At the far end of the room, as has already been noted, ceiling brightness is much more affected by the reflectance of the room surfaces than by *H*. The complex interrelationship between these two variables results in footcandle curves of the shape and relative magnitude shown in Figs. 9 and 10. A comparison of Figs. 7(A) and 7(B) and of 8(A) and 8(B), emphasizes the effect which these same two factors have on ceiling brightness near the cove and at a distance from it.

The variation in footcandle levels across the 12-foot width of the room was determined for several different installations by taking illumination readings along lines parallel to the cove at various distances from it. Fig. 11 shows a curve typical of the results of these measurements. The effect of *H* on average illumination levels is shown in the coefficient of utilization tables to follow.

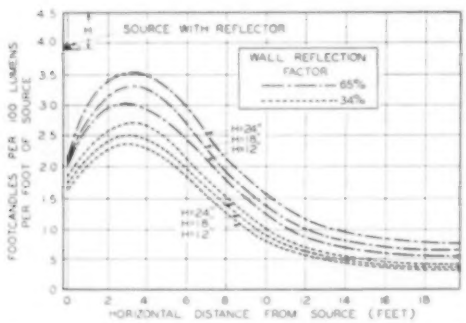


Figure 10. Footcandles on the working plane for three *H* values and two wall reflectances, T-12 lamps in 5-inch concentrating reflectors located as shown in Figure 4(A). Readings adjusted to 100 lumens per foot of light source. Measurements made at the center of a 12-foot cove section, at one-foot intervals starting from the center of the lamp along a line perpendicular to the axis of the cove. Reflection factor of ceiling, backwall, and inner surface of cove 85%.

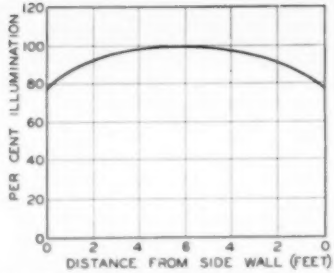


Figure 11. Illumination on the working plane in a line across the room parallel to a 12-foot cove. Curve represents results typical of readings at various distances from the cove, for several types of installations including both 65% and 34% wall reflectances.

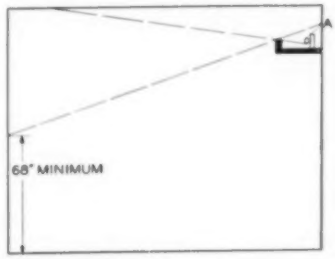


Figure 12. Diagram of sight lines determining location of top of cove lip. "A" designates edge of shadow created by corner of channel.

The dimensions of a cove should normally be such that the light source is concealed from view, and also such that the entire source produces direct illumination on most, if not all, of the ceiling. If a reflector is used, it must of course be considered as part of the source. In installations where a bare lamp is mounted in front of the channel, a shadow may be created on the backwall by the corner of the channel . In such cases the cove should be designed to hide this shadow, as well as the lamp and channel. The sharp upper edge of the shadow, designated by *A* in Fig. 12, may be located by drawing a line tangent to the lamp and the corner of the channel. The lower limit to which the cove lip must extend to accomplish the proper shielding is determined by a line from *A*, or, if no shadow is present, from the top of the lamp (or channel or reflector) to the upper limits of the most distant normal viewing position (see Fig. 12). The upper limit of the cove lip, to permit the source to be effective over the entire ceiling, is fixed by a line from the lower surface of the lamp to the farthest point on the ceiling. The intersection of these two lines locates the upper edge of the cove lip and thus determines cove width and lip height.

Multiple Rows of Lamps

It is sometimes desirable to use more than one row of lamps in a cove, either to produce a greater intensity of illumination than can be obtained with a single row, or to permit staggering the lamps to reduce "scalloped" effect. In most multiple-row installations, it is the intent of the designer to increase the brightness on the more distant portions of the ceiling without appreciably increasing the brightness of the backwall and the immediately adjacent ceiling area over that produced by a single row of lamps. Location of the lamps one above the other as in Fig. 13 is obviously the most desirable method to achieve this purpose. However, even with this arrangement, the interreflections between the lip and the floor of the cove and the backwall and ceiling make accomplishment of this aim difficult. The average backwall brightness with two rows of bare T-8 lamps was found to be approximately 165 per cent of that with one row of lamps, and with three rows it increased to 230 per cent. The brightness readings at all points on the ceiling were approximately additive. With three rows of lamps mounted one beside the other in the same horizontal plane, the brightness of the upper backwall and the immediately adjacent ceiling is approximately three times that produced by a single row of lamps, whereas the brightness of the more distant parts of the ceiling, because of the shielding effect of the front row, is increased considerably less than three times. Thus the location of the lamp rows in a horizontal plane produces greater brightness variation than the vertical arrangement, and the latter is to be preferred unless the physical features of the room or other considerations require the horizontal position.

Illumination measurements were made on similar installations utilizing one, two, and three rows of T-8 lamps mounted in a vertical line on 1¼-inch by ⅞-inch channels (Fig. 13). The distance of the lamps from the wall was chosen in accordance with previous determinations of the most desirable value for an 18-inch *H* distance. The cove width (15 inches) and lip height (1¾ inches) were fixed. Fig. 14 presents the results of these measurements, expressed in footcandles, per 100 lumens per foot of *cove length*. As was to be expected, when plotted on this basis, the curve representing the single-row installation is higher than the curves for multiple rows. This was caused partly by the trapping of light between and behind the lamps, and partly by the decrease in lumen output resulting from the higher-than-optimum lamp operating temperatures created by mutual heating effects. The relative overall efficiencies of the three installations, determined by averages of footcandle readings throughout the room, were as follows:

Single row	100%
Two rows	93%
Three rows	85%

Coefficients of Utilization

Once the average illumination produced by a cove under a specified set of conditions has been determined, it is possible to develop coefficient of utilization tables. The measured average footcandle values at three *H* distances for test installations with a 34 per cent wall reflectance and an 85 per

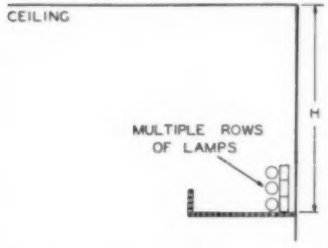


Figure 13. Mounting position of three rows of T-8 lamps used in investigation of multiple-row coves.

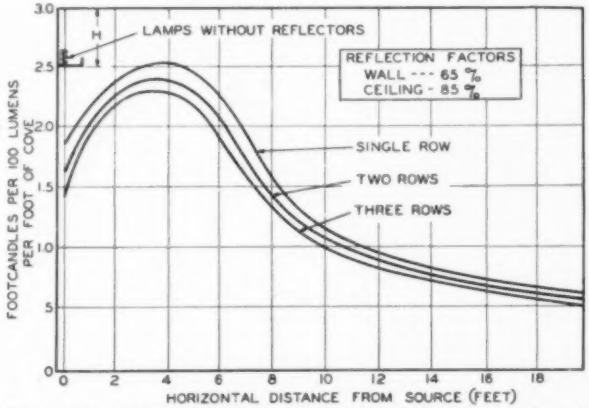


Figure 14. Footcandles on the working plane for one, two, and three rows of T-8 lamps mounted on 1¼" x ⅞" channel in arrangement shown in Figure 13. $H = 18"$, $P = 3½"$; width of cove 15", height of cove lip 1¾". Readings adjusted to 100 lumens per foot of *cove* length. Measurements made at the center of a 12-foot cove section, at one-foot intervals starting from the center of the lamp along a line perpendicular to the axis of the cove. Reflection factor of ceiling, backwall, and inner surface of cove 85%; walls 65%.

cent ceiling were first adjusted through the use of the interreflection method[1] to a 30 per cent wall reflectance and a 75 per cent ceiling reflectance. This necessitated correcting for the initial ceiling brightness without interreflections, for the loss of light due to decreased interreflections involving the ceiling, and for decreased interreflections from the walls. The coefficients of utilization thus obtained were then adjusted by means of the interreflection data to the room indices and reflecting surfaces commonly reported in coefficient of utilization tables, and the results are presented in Table II. Measured footcandle values for many of the other test installations described in the preceding sections were checked against these coefficients of utilization and found to be in very good agreement when corrected for room surface reflectances.

The figures presented are based on measured values obtained from a single-row bare lamp cove, with the inside of the cove surfaces painted flat white, and the backwall of the same reflection factor as the ceiling. As illustrated in the accompanying sketches, the lamps were mounted in front of the channel, although tests proved that the same coefficients of utilization can be applied to lamps placed over the channel. The measurements of *P*, the height of the cove lip, and the cove width were such that they fulfilled the requisites of good practice as established in the foregoing sections. However, the test results indicated that under these conditions the actual values of these three dimensions were of negligible importance in determining overall efficiency. Data on installations with reflectors compared to similar bare lamp installations showed that the effect of reflectors on the coefficient of utilization was also slight. For most of the tests, the addition of reflectors resulted in an increase of approximately five per cent in overall efficiency.

By comparison with most other types of lighting equipment, coves have several disadvantages from a maintenance standpoint. The large unprotected horizontal surfaces of most coves are especially subject to the collection of excessive amounts of dust. In addition, many coves are so inaccessible that no effort is made to provide maintenance except at the time of lamp replacement. Decorative coves are particularly likely to be neglected. For these reasons, relatively low maintenance factors must be assigned to cove installations. The authors feel that values of 60 per cent for good maintenance conditions, 50 per cent for medium conditions, and 40 per cent for poor conditions are reasonable.

Because of the many possible types of cove construction, the varied purposes for which coves are used, and the complex interrelationships between dimensions and reflectances, a complete investigation of the subject of cove lighting would be a task of considerable magnitude. The present study has been confined to an investigation of a simple rectangular cove, with a vertical surface or a quarter-section of a cylinder as a backwall, and equipped with fluorescent lamps, either bare or with reflectors. In addition to limiting the types of coves which were investigated, two assumptions were made in presenting the data: first, that an approximately uniform backwall and ceiling brightness is the ideal condition, and second, that complete freedom in the choice of cove dimensions is possible.

While the first of these assumptions is probably true for the majority of utilitarian coves, it is of course obvious that there are many installations, particularly those whose purpose is primarily decorative, where brightness uniformity is not desirable, and where a pronounced brightness variation may even be preferred. It is also obvious that the selection of the cove dimensions may be limited by any one of a number of considerations. The distance of the cove from the ceiling *H* is particularly likely to be determined by the architectural or structural features of the room, and the maximum permissible values of *H* and *P* are often dictated by appearance. Within these limitations, the data presented may be a guide in predicting the results to be obtained from a specific cove installation.

Table II.—Coefficients of Utilization

	Ceiling	75%			50%		
	Walls	50%	30%	10%	50%	30%	10%
	Room Index	Coefficients of Utilization					
	J	.10	.08	.06	.07	.05	.04
	I	.14	.11	.09	.09	.07	.06
	H	.17	.14	.11	.10	.09	.07
	G	.21	.17	.15	.13	.11	.10
	F	.23	.20	.18	.15	.13	.11
	E	.27	.24	.21	.17	.15	.14
	D	.31	.28	.26	.20	.19	.17
	C	.33	.30	.28	.21	.20	.19
	B	.34	.32	.30	.22	.21	.20
	A	.37	.36	.34	.24	.23	.23
	J	.11	.08	.06	.07	.05	.04
	I	.15	.11	.09	.09	.07	.06
	H	.18	.14	.12	.11	.09	.07
	G	.21	.18	.15	.14	.11	.10
	F	.23	.21	.18	.15	.13	.12
	E	.28	.25	.22	.17	.16	.15
	D	.32	.29	.27	.21	.19	.18
	C	.34	.31	.29	.22	.20	.19
	B	.35	.33	.31	.23	.21	.21
	A	.39	.37	.36	.25	.24	.23
	J	.11	.08	.06	.07	.05	.04
	I	.15	.12	.09	.09	.07	.06
	H	.18	.15	.12	.11	.09	.08
	G	.22	.18	.16	.14	.12	.10
	F	.25	.22	.19	.16	.14	.13
	E	.29	.26	.23	.19	.17	.15
	D	.33	.31	.28	.21	.20	.19
	C	.35	.33	.31	.23	.21	.20
	B	.37	.35	.33	.24	.23	.21
	A	.40	.38	.37	.26	.25	.24

[1] "The Interreflection Method of Predetermining Brightnesses and Brightness Ratios." ILLUMINATING ENGINEERING, Vol. XLI, No. 5, p. 361 (May 1946).

TELECAST

LIGHTING NEWS OF CURRENT INTEREST

Digest of March Executive Meeting, New York

The regular bimonthly meeting of the Council Executive Committee, held on alternate months between the general full meeting of Council, convened March 8, 1949, at I.E.S. headquarters, New York City.

Present were: C. H. Goddard, Walter Sturrock, Vice-Presidents; A. H. Manwaring, General Secretary; A. D. Hinckley, Executive Secretary; C. L. Crouch, Technical Director; and Frank Knowles, Chairman Membership Committee.

In the absence of President Lee E. Tayler, attending the Regional Conferences on the west coast, C. H. Goddard, Vice-President, presided.

Newest Membership Figures

After elections to membership as noted elsewhere in the news section, and other membership changes, the current membership totals were reported as follows:

September 30, 1948		March 8, 1949
6,516	Total Membership	6,899
21	Members Emeritus	25*
45	Fellows	43
1,406	Members	1,484
4,908	Associate Members	5,142
136	Student Members	205

New Sustaining Members

Favorable action of the committee resulted in the election of two new sustaining members as follows:

Ryall Electric Supply Company
1160 Stout
Denver, Colorado
Official Representative: C. O. Ryall

Schockett Electric Company
1061 Broadway Street
Denver 3, Colorado
Official Representative: Carl Schranz, Jr.

New Student Branch in Cincinnati

In his report as Chairman of the Local Activities Committee, Walter Sturrock presented a petition submitted by a group of enrolled students at the University of Cincinnati for the chartering of a Student Branch. Discussion of the requirements involved for action on such a petition, culminated in a vote that recommendation be made to Council for the chartering of a Student Branch at the University of Cincinnati.

New Local Representatives

Upon presentation by Mr. Sturrock, action was taken to confirm the appointment of local representatives of the Society in two new localities, as follows:

Charles R. Minors—Rome, Georgia

H. L. Bray—Medford, Oregon

Other pertinent matters discussed by the committee included: the appointment of Stuart R. Williams, Chairman of the Committee on Street and Highway Lighting, to serve as the Society's representative on the Committee on Engineering at the President's Highway Safety Conference; the appointment of additional members to the Society's technical committees; a proposed Society brochure; and a number of general office operational procedures.

Illuminating Engineering Reprints

To provide readers as well as authors with quantities of reprints of articles, it is planned to hold future issues of Illuminating Engineering in type for about four weeks following publication. Orders should be submitted to the Publications Office, Illuminating Engineering Society, 51 Madison Avenue, New York 10, N. Y. As the cost of reprinting varies with the number of pages and the quantity ordered, prices for a specific item will be submitted on request. While many authors follow the practice of getting a small quantity of reprints for their own use, the Publications Office does not in general have sufficient extra copies for possible continued demands.

New I.E.S. Lighting Data Series Available Soon

The first seven sheets of the new I.E.S. Lighting Data Sheets, Series XIV, will be ready for distribution to subscribers in the very near future.

Selected and prepared by the Sub-Committee on Technical Data Sheets, Series XIV comprises 24 sheets, each describing one of a number of types of lighting installations, giving detailed description with photographs and technical data. Residential, store, office, industrial and other special lighting problems are included. Previous series which are well-known to Society members are now widely in use by individual members, lighting equipment manufacturers, electrical wholesalers and contractors, utilities and I.E.S.-sponsored lighting courses.

A new feature of the Series XIV distribution is that an entirely new and attractive but inexpensive binder may now be obtained for use in protecting the sheets on the office reference shelf or in the field.

While these Data Sheets will appear regularly in the pages of Illuminating Engineering as a service to members, the sheets printed on especially heavy coated paper and punched for binder use may be obtained only by regular subscription. (See page 4A.)

Committee Appointed on Professional Requisites

President L. E. Tayler and the Executive Committee explored in some detail at their February meeting the question of the professional status of the Society. In concept, this is similar to the problems facing all engineering organizations which have faced active consideration of state laws on professional engineering registration. Three years ago Council approved recommendations submitted to it by a special Task Committee assigned to study the problem. These recommendations were as follows:

(1) Since licensing or registration of engineers is to all intents and purposes an accomplished fact in 47 states and three territories and the requirements for registration in these states

are tending to become more severe, it is recommended that each member of the Illuminating Engineering Society who is qualified, give consideration to registration and obtaining a license to practice as a professional engineer in his own state now while this may be accomplished with the least complication. Application should be made to the State Board of Registration for Professional Engineers, generally located in the capitol of each state.

(2) Believing that it is desirable to have "illuminating engineering" recognized as a branch of engineering in all those states which issue licenses for practice in separate branches, it is recommended that the Illuminating Engineering Society use its influence in this direction, working through the individual registration boards in the various states and the National Council of State Boards of Engineering Examiners.

(3) It is recommended that the Society, in all pertinent activities, consider "illuminating engineers" as professional men and women and encourage the growth of professional consciousness in the Society membership.

Since the approval of the above, no report has been submitted to Council and no record exists as to whether the objectives of the recommendations have been furthered. In general, most laws are becoming more strict—a movement parallel to the growth of the Society of Professional Engineers.

To investigate the entire matter with a view toward "defining and improving the professional status of Illuminating Engineers, especially in reference to Society membership" Council has established a Committee on Professional Requisites and asked Berlon C. Cooper and F. I. Wilson to serve.

Technical Problems of Central Station Lighting to Be Studied

After favorable action by letter ballot, Council has approved a technical committee to examine the "Lighting of Central Station Properties." Mr. A. A. Brainerd, of Philadelphia Electric Co., has been appointed chairman. Messrs. R. S. Bucher, Buffalo Niagara Electric Corp., H. A. Cook, Detroit Edison Co., C. E. Egeler, General Electric Co., Walter B. Morton, Pennsylvania Power and Light, L. G. Parks, Ebasco Services, Inc., and D. H. Tuck, Redding Ridge, Conn., have been invited to serve under Mr. Brainerd.

The scope of the committee has been defined as a study of the lighting of electric power generating plants and their power distribution facilities. Among other things, this will include the lighting of meter panels and control rooms.

Section Status for British Columbia

With all constitutional requirements met, the British Columbia Chapter was officially approved for Section status at the Council meeting in February. This makes the third Section for Canada, and the twenty-fourth in the organization of the Illuminating Engineering Society.

Mr. A. E. Simpson of Vancouver, B. C., is present chairman of the new Section, and A. M. Hurly, Canadian General Electric Co., Vancouver, is secretary.

An Important Message to All I.E.S. Members

The following message, signed by R. W. Butts, Chairman, Conference Executive Committee, is of importance to all I.E.S. members:

"September 19-23, 1949, is an important week to remember, for it is the date of this year's National Technical Conference at French Lick, Ind.

"The 1949 Conference will be no ordinary convention. For one thing, all meeting halls, dining areas and other rooms are in the hotel building. This means that every member attending is in close touch with the business, sports and entertainment activities of the Conference and with his fellow members.

"The location enhances such fellowship, for this famous resort hotel is situated in the midst of a huge estate of some 2,000 wooded, rolling acres. Geographically, French Lick is in the Cumberland foothills of Southern Indiana, removed from the sounds of big cities and the pressure of the business world. Excellent facilities for golf, swimming, bowling, trap-shooting, archery, hiking, riding and other sports provide a rare opportunity to combine business with pleasure and relaxation. Not to be overlooked is excellent food (included as part of the hotel cost) and the well-known therapeutic baths and mineral water.

"The technical program begins on Tuesday, September 20. Many valuable and interesting papers will be presented in a schedule which minimizes the need for parallel sessions. The Lighting Service Forum will be held on Monday afternoon, September 19.

"It's French Lick in 1949, the best Conference ever!"

New Color Computing Device Developed

One hundred million "colors" can be distinguished by a new Librascope Tristimulus Integrator announced by the General Aniline and Film Corporation. An automatic computer, it integrates the data obtained by the Hardy Spectrophotometer so that colors are measured and analyzed with extreme accuracy in a few minutes. The new device may be added to existing spectrophotometers with only minor modifications.

Prior to the invention of the Tristimulus Integrator, the use of numerical specifications in colorimetric problems was difficult. It was necessary to rely on the eye for detection of color differences or broadly descriptive words to convey quantitative differences. The new computer multiplies quantity data at each wavelength and sums up the products to obtain the three numerical components of the I.C.I. Tristimulus system.

Calculux—New Illumination Indicator

A new Illumination Levels Indicator has been recently developed by the Holophane Company, New York, and is being distributed free upon request by that company. Termed a "calculux" the device may be readily used by anyone for determining suggested lighting levels for the "economic rate of performance" of any task.

Illumination levels indicated by the Calculux are based on the H. C. Weston data developed in England under the sponsorship of the Medical Research Council and the Department of Scientific and Industrial Research of the British Government.

The Calculux, of wheel-type construction comes complete in a carrying envelope with a booklet of simple instructions. It may be obtained without charge on request to the Department of Applied Research, Holophane Company, Inc., 342 Madison Avenue, New York 17, N. Y.

South Pacific Coast Regional Conference

The first Regional Conference held early enough to hit the April issue has reported an especially successful two-day meeting. This was the fifth annual Regional Conference of the South Pacific Coast Region held March 3 and 4 at San Francisco. The conference was sucessful from several points of view—the quality of the program, the large attendance and the representation of interested persons not members of the Society, including architects, school officials and retail store owners and managers. There was a total registration of 375 during the two days, with delegations present from Utah, Nevada and Arizona as well as from numerous parts of California. A large group attended from Southern California. The conference was held in the auditorium of the Pacific Gas and Electric Company.

The program was divided into four sessions, each intended to be of particular interest to some but having general interest for all. The papers presented were grouped under the themes of the four sessions: Sources, Design, Store Lighting and School Lighting. Invitations to store owners and to school trustees and administrative officials were issued especially for the latter two sessions.

On the lighter side of the conference, an informal party in honor of President and Mrs. Lee E. Tayler was held Thursday evening at San Francisco's famous Chinese night club, The Forbidden City. Officers of the sections, program speakers and the regional conference committee and their wives attended.

A welcome to the conference was expressed at the opening session by O. R. Doerr, vice-president of the Pacific Gas and Electric Co., who was introduced by S. H. Hazelton, Jr., chairman of the Northern California Section. President Tayler formally opened the conference with his President's Address in which he reviewed the question of professional qualifications and the legislation in various states regarding registration of professional engineers. He stressed the importance of the work of the standing committees in the functioning of the Society and spoke on the need of organizational changes because of the growing membership. Financial affairs of the Society also were reviewed.

Featured on the Conference program were:

Thursday — March 3

Address of Welcome—O. R. Doerr

President's Address—L. E. Tayler

Recent Developments in Incandescent Lamps—Charles R. Long, Westinghouse Lamp Division, Los Angeles

Recent Developments in Electric Discharge Lamps and Circuits—J. W. Howard, General Electric Co., Los Angeles.

Lighting and Architectural Design—Victor Gruen, Gruen & Krummeck, Los Angeles.

Applied Brightness Engineering—W. G. Darley, Consulting Engineer, Austin, Texas.

Modern Instruments for Lighting Measurements—Prof. Dan M. Finch, Univ. of California, Berkeley.

Friday — March 4

Pros and Cons of Light Sources, Systems and Color—Don P. Caverly, Sylvania Electric Products Inc., New York.

The Economics of Store Lighting—Kenneth Welch, Grand Rapids Store Equipment Co., Grand Rapids, Mich.

The Design of Louvers and Louverall Systems—Wentworth Potter, General Electric Co., Cleveland, Ohio.

The I.E.S. Recommended Practice for Store Lighting—Oscar Meissner, Bureau of Light and Power, Los Angeles.

Lighting and Child Development—Dr. D. B. Harmon, School Consultant, Austin, Texas.

Sampling School Lighting in California—Doyt Early, A.I.A. Division of Schoolhouse Planning, Sacramento.

The American Standard Practice for School Lighting—Dr. Leland H. Brown, Stanford University, Palo Alto.

Regional Vice-President's Address—T. H. Shepherd, Bureau of Light and Power, Los Angeles.

The committee members responsible for the successful conference were John S. Walsh, Conference Chairman; Prof. Dan M. Finch, papers, Gordon Black, reception, A. C. Anderberg, membership, C. T. Bakeman, attendance, George Smedberg, decorations and Harry McMasters, publicity.

Southwestern Regional Conference at Houston

The South Texas Chapter will play host to the Southwestern Regional Conference at Houston, Texas this month, details of which should make good reading in the next issue. They are making preparations for the attendance of 200 men and women prominent in the lighting industry in the Southwest.

A joint meeting will be held on Monday noon, April 11, in conjunction with the monthly luncheon of the Houston Engineering Club, with C. M. Cutler of the Lamp Department, General Electric, Cleveland. Other features of the program will be a paper by Don Caverly of Sylvania on "The Pros and Cons of Light Sources and Light Systems"; Store and Office Installations by W. E. Folsom; Lighting As We See It by L. M. Wallace of Westinghouse, St. Louis; Color Conditions for Industry; Classroom Planning; Hotel Lighting; Chemical Plant

SOUTH PACIFIC Coast Regional Conference, San Francisco, March 3-4. At left, portion of large attendance of 375. At right, Pres. Lee E. Tayler in Mandarin costume, with two Chinese show girls at the Forbidden City, during the Conference's lighter moments.

Lighting; Lighting in the Oil Industry, and Lighting for Filling Stations. An inspection trip will also be conducted of downtown Houston stores and the newly lighted Shamrock Hotel.

Northeastern Regional Conference in May

The Northeastern Regional Conference for 1949, coming up May 12 and 13, is now about set with plans for a very important gathering. The meeting will be held in Hartford, Connecticut in Sentinel Hill Hall of G. Fox & Co. Many I.E.S.'ers of the New York and New England Sections will recall the exceptionally fine regional conference of 1941 at which the Connecticut Chapter was host and received its charter. Now it's Connection *Section*, and host once again to the Northeastern group.

Outline of the program shows: In three parallel sessions on Thursday, May 12, papers on commercial lighting (Store Lighting from Management's Viewpoint; Symposium on Planned Lighting) — industrial lighting (Planned Industrial Lighting; High Bay Lighting; Color Applications)— residential lighting (Trends in Home Lighting; Color in the Home; Customer Lighting in the Home).

On Friday, May 13 there will again be three sessions. A general session will feature "What I.E.S. Is Doing for You." The technical session will be on gaseous tubes, operating equipment and plastics in lighting. A parallel session on street lighting will cover "The Need and Present Equipment; New and Recent Developments; and the Future in Street Lighting." A luncheon meeting is also planned for Friday afternoon which will present a symposium on Planned School Lighting.

First Student Branch Receives Charter

The first student branch of the Illuminating Engineering Society, which was organized last year at the University of Illinois, received its charter recently at a special presentation meeting. G. K. Hardacre, past-president of I.E.S., presented the national charter to Chairman Lowell Shepard at the group's March 9 meeting. Following the presentation, Mr. Hardacre spoke to the group on "Advice to the Young Engineer."

The University of Illinois, where the new student branch functions, has a specialized curriculum in illuminating engineering. J. O. Kraehenbuehl, professor of electrical engineering and Fellow of I.E.S., who was instrumental in the formation of the student branch, is the head of the Illumination option, organized two years ago.

CHARTER presented to first Student branch of I.E.S., organized at the University of Illinois. Witnessed by Prof. J. O. Kraehenbuehl, left, charter is presented by G. K. Hardacre, right, to Chairman Lowell Shepard at special Charter-Night ceremonies.

Lighting Fundamentals Course Available

The I.E.S. Lighting Fundamentals Course outline, developed by the Committee on Lighting Education is now available from Society headquarters. The outline, multilithed on 8½ x 11-inch sheets and mounted in a leather binder, is priced at $1.00 for a single copy; 75 cents in quantities of ten or more.

The book gives the complete outline for a fundamentals course in illumination covering:

I. Theory of Light; the Eye; Partnership of Light and Sight.
II. Illumination Terms; Laws; Controls; Systems; Meters.
III. Electric Filament Lamps; Mercury Lamps; Glow Lamps.
IV. Fluorescent Lamps.
V. Illumination Design — Lumen Method.
VI. Industrial Lighting.
VII. Office and School Lighting.
VIII. Store Lighting.
IX. Exterior Lighting.
X. Residential Lighting.
XI. Fundamentals of Home Wiring.
XII. Lighting Economics.

Inquiries should be directed to the Executive Secretary, A. D. Hinckley.

New High-Reflectance Desk Linoleum

For more than ten years, the I.E.S. Committee on Office Lighting has emphasized the value of light desk top surfaces for improving brightness ratios in the field of view. With wood desks, the recommended surface could be achieved only by bleaching or painting; for metal desks it was limited by the commercial availability of the proper linoleum or other surface material.

The Armstrong Cork Company of Lancaster, Pa., has now introduced two patterns which meet the objective of the 30-35% reflectance range recommended by the I.E.S. Office Lighting Committee. Both are of the simple striated type identified by the manufacturer as jaspe materials. The Armstrong catalog numbers are 415 for a blond-tan, and 416 for a mist-green pattern, both in the 30-35% reflectance range. The ease of cleaning linoleum makes certain that this value can be maintained.

The accompanying photograph indicates the major improvement which results with the use of light-colored linoleum materials. The brightness ratios between the office tasks and the immediate surrounds is significantly reduced.

The photograph also shows the improvements yet to be realized in office

JASPE linoleum desk-top surfaces, recently made commercially available, are here being demonstrated by R. L. Oetting, Chairman of the Committee on Office Lighting.

furniture and equipment. Lighter finishes on the order of 35% reflectance are recommended for office desks, tables, files and machines by the Office Lighting Committee. Most of the finishes used in the past have had a reflectance on the order of 5%.

Photosensitive Glass Achieves Louver Effect

Development of a new lighting technique, involving the use of Corning's photographic medium, photosensitive glass, will be demonstrated at the Third International Lighting Exposition in Chicago. To be commercially known as "Fota-lite," the new material is offered as an improved form of louver panel.

Photosensitive glass permits the reproduction of three-dimensional images or designs. Thus, the louvers, in the form of planes of opalescence, can be ingrained in cellular or other patterns throughout the width, length and depth of a one-eighth inch thick pane of glass. Since the louvers are embedded in the glass, an important advantage appears in that fixtures can be sealed to prevent the accumulation of dust on lamps and reflectors. Cleaning and maintenance of the luminaire may be rendered more simple through the use of this thin glass pane which allows shallower lighting fixtures than possible with plastic or metal louver construction. No selective absorption is anticipated and therefore no change in the spectral composition of the light.

At normal viewing distance, the glass appears to be solid opal because of the small cell sizes, less than one-sixteenth of an inch in diameter. At the same time light directed vertically from the luminaire is unrestricted except for a slight surface diffusion which serves to obscure the lamps. Brightness at high angles is quite low. Initial samples have been based on a 45-degree cut-off although this could be varied by the basic photographic process.

Lighting Courses Still Hold Spotlight

The complete program of the New England Section's Lighting Course has been received at Headquarters. It confirms the preliminary reports which indicated that it would be a comprehensive, advanced study of key lighting topics.

Speakers and subjects covered during the eight-sesssion course (March 15-May 10) include F. J. Vorlander, Champion Lamp Works, on Developments; M. Kruger of A. L. Smith Iron Company, on Store Lighting; and H. A. Klopot, of Ainsworth, Garey and Century on Display Lighting; W. Thompson, Thompson Engineering Company, on Office Lighting; L. S. Cooke, General Electric Company, on School Lighting; R. L. Smart, Boston Edison, on Sports Lighting; W. R. Wilson, Westinghouse Electric Corporation, on Industrial Lighting; Miss J. Reynolds, Sylvania Electric Products, Inc., on Home Lighting; J. C. Forbes, General Electric, Maintenance of Lighting Installations.

From New York City comes the announcement of its third lighting course to be added to the two described in the February issue of ILLUMINATING ENGINEERING. This is sponsored by the American Institute of Electrical Engineers, although I.E.S. members are taking an active part in handling the seminars. The program began on March 8 and will continue through seven consecutive Monday sessions. Subjects include: General Lighting Equipment and its application; Specialized Lighting Equipment and its Application; Circuit Design and Installation; Auxiliary Equipment; Operation and Maintenance Problems; Code Rules and Regulations; Economics of Lighting.

The Northern California Section has just completed two twelve-week courses in Lighting Fundamentals, with parallel sessions in San Francisco on Monday evenings and Oakland on Wednesday evenings. The courses were under the direction of John S. Walsh, Educational Chairman, with speakers drawn from the section membership. Attendance at the two courses totaled 60. A similar course, under the direction of Clark Baker, Educational Chairman, is now being given in

GRAYBAR managers entertained by Day-Brite Lighting, following sales conference in St. Louis. Shown at portion of head table of the banquet are, left to right: O. W. Klingsick, V-P of Day-Brite; A. H. Nicoll, Pres. of Graybar; D. J. Biller, Pres. of Day-Brite; G. F. Hessler, V-P of Graybar; J. F. Whitehead, Jr. (Day-Brite); R. C. Kinney (Graybar) and Willard Brown (General Electric).

ON COMPLETION of a twelve-week Course in Lighting Fundamentals in San Francisco, Lawrence Casey receives a certificate from John S. Walsh, Educational Chairman of the Northern California Section.

Sacramento, by the new Mother Lode Chapter, with the same speakers. Enrollment in the Sacramento course is 47.

The courses were designed primarily to interest architects, contractors, fixture designers, interior decorators and others in the how and why of modern lighting. Lectures are of the discussion type with sound slide films, demonstrations and practical problems, with copies of I.E.S. Recommended Practices, reprints of pertinent articles, etc., distributed.

A course for architects was recently conducted by the Western New York Section. Featured as a series of six two-hour weekly meetings for members of the Buffalo Chapter of the American Institute of Architects and their associates, the course, "Elements of Electric Wiring and Illumination," was conducted during December and January.

The meetings were devoted to the services and requirements of the Buffalo Niagara Electric Corporation, which serves the Buffalo area; the third and fourth meetings covered elementary wiring design and National Electrical Code practice. The last two meetings covered simple lighting calculations and the practical requirements for quality of lighting and effective, comfortable seeing.

The average attendance at these six meetings was 78, with a peak attendance of 107. Thirty-eight members of the AIA attended one or more meetings, with about 20 others, not members of the AIA but associated with architects' offices. Sixteen individuals of the offices of consulting engineers were present at some or all of the meetings.

ABOUT PEOPLE

George J. Taylor of Day-Brite Lighting, Inc., has been appointed Eastern Sales Manager of that company, according to a recent announcement. Mr. Taylor, with headquarters in New York City, will be in charge of a territory covered by the New England States, New York State, Pennsylvania, New Jersey, and Washington, D. C. Mr. Taylor joined the Day-Brite organization in 1947, after a very active career in the lighting industry, with the Cooper-Hewett Co., and for a number of years with the General Electric Co., at Nela Park and the company's Atlantic Division in New York City. He has figured prominently in the design of many outstanding lighting installations, and is especially well known for his design and development work in connection with high-intensity mercury vapor lamps, and RF fixtures and lamps for industrial use.

Lawrence H. Beck has been appointed representative in the Michigan territory by the Solar Light Manufacturing Co., effective March 1, 1949. Mr. Beck has had experience both as a representative and in lighting and is expected to be of assistance to architects, engineers, contractors and distributors. He will make his headquarters at 141 West Parkhurst Place, Detroit 3, Mich.

W. D. Gorman, considered by his fellow Connecticut Section members to be "dean of Illuminating Engineering" in the northeast, retired last month from the Hartford Electric Light Co., after 40 years of service. Mr. Gorman, who was instrumental in forming the Connecticut Chapter and was its first chairman, was honored by a dinner meeting of the Section on February 24. He announced in his speech before this gathering that he intends to set up an agency for lighting consulting in Hartford.

Victor J. Oellette, Vice-Chairman of the Connecticut Section, was promoted to manager of commercial sales for the Hartford Electric Light Co., Hartford, Conn., as of January 1, 1949. Mr. Oellette is a graduate of Trinity College, and has been with the Hartford Electric Light Co. since 1929.

To handle the export sales of Colonial Electric Products, Charles L. Sabatini, president, has announced the appointment of **Joseph Plasencia.** Mr. Plasencia has already left on a three-month, fifteen-country trip to examine foreign markets for cold cathode lamps and fixtures.

A. T. Bergeron has been elected a vice-president of the Miller Company, Meriden, Conn., thus adding to his duties as manager of the Illuminating Division of that company. Mr. Bergeron's headquarters will continue to be in Meriden. While Mr. Bergeron is well known nationally, lighting people on the Pacific coast in particular will remember him because of his many years' residence in that area.

R. A. Potter has been transferred by Westinghouse to Salt Lake City to handle street lighting in that area. Thus he shifts allegiance from the New England Section of I.E.S. to the Utah Chapter. Mr. Potter is a Yale graduate and has been in active lighting work in New England for twenty-five years.

The appointment of **C. B. Swann** as Sales Engineer has been announced by Pittsburgh Reflector Company, Pittsburgh, Pa. In the lighting field since 1930, Mr. Swann, before joining Pittsburgh Reflector was connected with the lighting division of the Westchester Lighting Company. In his new position as Sales Engineer for the Pittsburgh area, he will render consultation service to commercial and industrial users of lighting equipment.

Jules Levenstein, long associated in the lighting industry, has acquired the active interests of the Ender Manufacturing Corp., specialists in commercial and industrial luminaires.

Carl R. Busch has been appointed district lighting engineer for the Eastern District of Westinghouse. His responsibilities include primarily New York City and State, plus northern New Jersey. Mr. Busch is a graduate of Ohio State University and has previously been employed by both Holophane and the Pittsburgh Reflector Co.

LOCAL MEETINGS

ALLENTOWN, PA.

An active I.E.S. program on lighting education is underway again this year in the Eastern Pennsylvania Chapter. This Chapter, as was reported at the Local Activities Conference last year, practices the unique plan of holding most of its regular meetings each in a different town. As a result, members throughout the Chapter take an active part in Chapter affairs.

Currently underway is a lighting course on "Illumination Fundamentals and Application," for which instructors and educational committee workers are recruited from a number of the Chapter's more or less outlying towns. Some 50 architects are attending the course which has been organized and is under the direction of Frank E. Heins of Reading, Pa. Classes are held in Allentown for seven sessions with instructors from a number of cities throughout the Eastern Pennsylvania Chapter. An enrollment fee of $10.00 pays for text books, handbooks, quiz papers and a "graduation" dinner.

CHICAGO

At the invitation of the Student Chapter, I.E.S., at the University of Illinois, Chicago has scheduled a trip to Urbana as part of its regular section program. The date selected is May 6. An active day is forecast, including an inspection tour of the campus, particularly the electrical engineering buildings, and a special lighting program in the photometric and illumination research laboratories.

CONNECTICUT SECTION

The February 24 meeting of the Connecticut Section, scheduled as Charter presentation night for the new Section, developed into a much greater occasion for its principal speaker. W.

Continued on page 248

LIGHTING CALENDAR

Society Events

April 10-12, 1949—Southwest Regional Conference, Houston Texas

April 28-29, 1949—Canadian Regional Conference, Toronto, Canada

May 12, 1949—Meeting of I.E.S. Executive Committee, Hartford, Conn.

May 12-13, 1949—Northeastern Regional Conference, Hartford, Conn.

May 23-24, 1949—Great Lakes Regional Conference, Rochester, N. Y.

June 6-7, 1949—East Central Regional Conference, Harrisburg, Pa.

June 8, 1949—Meeting of I.E.S. Council, 51 Madison Avenue, New York, N. Y.

June 9, 1949—Local Activities Conference, New York, N. Y.

June 9, 1949—Meeting of Council Executive Committee, New York, N. Y.

July 13, 1949—Meeting of I.E.S. Executive Committee, Philadelphia, Pa.

September 19-23, 1949—National Technical Conference, French Lick Hotel, French Lick, Ind.

Industry Events

April 5-7, 1949—Edison Electric Institute, 15th Annual Sales Conference, Edgewater Beach Hotel, Chicago, Ill.

April 18-20, 1949—Midwest Power Conference, Sherman Hotel, Chicago, Ill.

April 12-13, 1949—Canadian Electrical Distributors Association, Annual Meeting and Conference, General Brock Hotel, Niagara Falls, Ontario, Canada

April 19-21, 1949—American Institute of Electrical Engineers, South West District Meeting, Baker Hotel, Dallas, Texas

April 24-26, 1949—Texas Optometric Association, Annual Convention, Galveston, Texas.

April 25-28, 1949—Fourth Southern Machinery and Metals Exposition, Municipal Auditorium, Atlanta, Ga.

May 2-4, 1949—American Society of Mechanical Engineers, Spring Meeting, Hotel Mohican, New London, Conn.

May 2-6, 1949—National Electrical Wholesalers Association, 41st Annual Convention, Netherland Plaza Hotel, Cincinnati, Ohio.

May 7, 1949—Eastern Electrical Wholesalers Association, Dinner and Dance, Hotel Astor, New York, N. Y.

May 16-19, 1949—National Fire Protection Association, 53rd Annual Meeting, Fairmont Hotel, San Francisco, Calif.

May 30-June 10, 1949—Canadian International Trade Fair — Exhibition Grounds, Toronto, Canada

May 31-June 2—Edison Electric Institute, Annual Meeting, Traymore Hotel, Atlantic City, N. J.

June 5-9, 1949—The American Society of Refrigerating Engineers, 36th Spring Meeting—Cruise; St. Lawrence and Saguenay Rivers starting from Montreal

June 20-22, 1949—American Society of Heating & Ventilating Engineers, Semi-Annual Meeting, Minneapolis, Minn.

June 20-24, 1949—American Institute of Electrical Engineers, Summer General Meeting, New Ocean House, Swampscott, Mass.

June 28-30, 1949—Canadian Electrical Association, Annual Convention, Banff Springs Hotel, Alberta, Canada.

July 2-9, 1949—New York State Association of Electrical Contractors & Dealers, Inc., Golden Anniversary Convention, Saranac Inn, N. Y.

August 23-26, 1949—American Institute of Electrical Engineers, Pacific General Meeting, Fairmont Hotel, San Francisco, Calif.

October 11-14, 1949—American Standards Association, Annual Meeting, Waldorf-Astoria Hotel, New York, N. Y.

October 17-21, 1949—American Institute of Electrical Engineers, Netherland Plaza Hotel, Cincinnati, Ohio.

October 24-28, 1949—37th National Safety Congress, Chicago, Ill.

November 13-18, 1949—National Electrical Manufacturers Association, Chalfonte-Haddon Hall, Atlantic City, N. J.

December 4-7, 1949—The American Society of Refrigerating Engineers, 45th Annual Meeting, Edgewater Beach Hotel, Chicago, Ill.

Continued from page 247

D. Gorman, first chairman of the Connecticut Chapter, was scheduled to address the Section on "The History of I.E.S. in Connecticut," but he never did get to speak. Unknown to Mr. Gorman, the entire Section conspired to surprise him with a dinner meeting in honor of his pending retirement from the Hartford Electric Light Company. Secret meeting notices went to all members except Mr. Gorman, featuring "Bert Gorman Nite"—and the surprise to Mr. Gorman was quite complete.

More than 100 men attended the dinner, many of them from several other Sections and Chapters. C. M. Synder, General Electric Co., Boston, was toastmaster. Some of the speakers honoring Mr. Gorman's service to lighting and to the I.E.S. included: R. D. Cutler, Vice-President of the Hartford Electric Light Co., S. G. Hibben, Westinghouse Electric Corp., Bloomfield, N. J., J. M. Ketch, General Electric Co., Cleveland, Ohio, Preston S. Millar, Electrical Testing Laboratories, Inc., New York City, C. C. Keller, Holophane Co., New York, Lawrence Walker, General Electric Co., Bridgeport, Conn., G. W. Beals, Miller Co., Meriden, Conn., among others.

Mr. Gorman was presented with a traveling bag and an engraved pen and pencil set, as a gift from the Connecticut Section members.

Hartford, Connecticut had its first Planned Lighting Show this past winter, and though report of it was delayed, some details are well worth recording. The first full-scale lighting show since 1937 in Connecticut, the exhibition was held at the Hartford Times Radio Center and drew an attendance of more than 15,000 during the three-day sessions. Twenty different manufacturers exhibited at the show. The committee in charge was: V. J. Oellette, Chairman; with W. D. Gorman, Hartford Electric Light Co.; P. V. Hayden, Connecticut Light and Power Co.; and S. F. MacLean, United Illuminating Co. All of the committee personnel were members of the Connecticut Section of I.E.S., and their companies, who sponsored the show, are Sustaining Members of the Society.

New York

The March meeting of the New York Section was a unique program developing from the Section's Technical Forum (Study Club) programs. During the year, the Technical Forum, which held its studies in the afternoons preceding the regular Section meetings, based all of its programs on some technical aspect of color and its relation to lighting. Leading authorities in this field were the principal speakers and a very valuable Forum on Color was developed.

For its March program, a symposium of these programs was presented, sponsored jointly by the Section and the New York Technical Forum. Four chief color problems were discussed:

"Development of Color Standards; Technical Advances in Color Engineering in the Manufacture of Illuminants; Surface Color Problems Related to Paints and Textiles; The Consumers' Side of the Color Picture."

Technical color experts participating were: Dr. I. H. Godlove, Director of Research, General Aniline and Film Corporation; Eugene W. Commery, Director of Residential Lighting, General Electric Company; Carl Foss, Color Research Engineer and Consultant, Princeton, N. J.; E. I. Stearns, Assistant Director, Physics Section, Research Department, Calco Chemical Division, American Cyanimid Company, Bound Brook, N. J., and Frederick H. Rahr, President, Rahr Color Clinic, New York, N. Y.

With Mr. Foss as Moderator for the symposium these recognized authorities reviewed and continued their discussions developed previously at the Technical Forum meetings.

San Francisco

Some of the officers of I.E.S. have been urging for some time a closer liaison with the electrical contracting field. They felt that the Society's programs had much of value for electrical contractors and vice versa.

It is interesting to note, therefore, that the Northern California Section, at its February 10 meeting, devoted its entire program to this very purpose. Featured at the meeting was William J. Varley, executive manager of the San Francisco Electrical Contractors Association, who spoke on, "The Contractor's Place in Illumination."

He said that opportunity exists for contracting organizations to develop their own lighting design staffs and sales forces. He announced also that the National Electrical Contractors Association intends to remove the exemption imposed on lighting equipment in the association's program for guaranteeing members' workmanship for one year after installation. Some 100 I.E.S. members and electrical contractors attended this interesting program.

Ideas from Other Sections and Chapters

It is interesting to note, from impersonal headquarters, the various ideas different Sections and Chapters have for encouraging attendance; making their I.E.S. organization a real civic asset, making their programs pleasant as well as instructive, and innumerable other things. For example:

The Chicago Section has instituted a coffee and doughnuts social hour following its regular meeting. A secondary benefit from attending the programs has been good fellowship and a closer acquaintance with other Section members.

The Michigan Section uses one page of its program notices for "I.E.S. Notes." These list Regional Conference dates, a reminder (with page numbers) to read about the French Lick Conference in Illuminating Engineering, asking for ideas on next year's programs and other pertinent and interesting items.

The Oregon Section, among other and more usual committee chairmen, have regularly assigned chairmen for such activities as home lighting, school lighting, data sheets and an historian, thus using member talent and special interests for the good of the whole Section program.

The Milwaukee Chapter, with its first meeting notice back in October, enclosed a list of the entire year's programs, giving time, place and subject. If eleven programs (as Milwaukee planned) can be established that far ahead of time, it seems a good way of getting advance billing.

The Montreal Section meeting notices prominently feature both the current meeting program and the next one coming up. They feel it keeps the date open for their next meeting.

The Georgia Section has a different design for each meeting notice—the motif tying in with the type of program. Their first notice of the year, for instance, was a replica of the cover of *Time* magazine—theme, "It's Time for I.E.S." December had a Christmas motif and subsequent notices were appropriate to the meeting subject.

The Ottawa Chapter notice devotes one column of its three-fold space to "Council Fire Gleanings"—brief local and Chapter news.

The Utah Chapter, relatively new in the family, saves funds with a meeting notice neatly printed on I.E.S. stationery. Very arresting, too.

NEW MEMBERS

At the meeting of the Council Executive Committee held on March 9, 1949, the following were elected to membership:

Baltimore Chapter

Associate Members:

Cornblatt, Sol J., 3010 W. Garrison Ave., Baltimore, Md.

Cremona, Frank P., 744 Poplar Grove, Baltimore, Md.

Street, Bernard H., Baltimore Lighting Supply Co., Baltimore, Md.

Skrupski, John, Broadway Electric Co., Baltimore, Md.

Weisblatt, Joseph D., D. & H. Electric Co., Baltimore, Md.

British Columbia Chapter

Associate Members:

Gordon, D. S., B. C. Electric Railway Co., Ltd., Vancouver, B. C., Canada

McGregor, D., Miss, B. C. Electric Railway Co., Ltd., Vancouver, B. C., Canada

Manlove, B. G., W. Freeman & Sons, Vancouver, B. C., Canada

McRoberts, Harvey E., McRoberts Electric Co., Vancouver, B. C., Canada

Thornton, R. C., B. C. Fluorescent Sales & Service Ltd., Vancouver, B. C., Canada

Student Member:

McCorquodale, Wm. A. H., University of British Columbia, Vancouver, B. C.

Capital Section

Associate Member:

Bransdorf, Richard R., Doubleday-Hill Electric Co., Inc., Washington, D. C.

Central New York Chapter

Associate Members:

Cortright, Wilbur S., Cortright Electric Co., Ithaca, N. Y.

Lee, Fred N., Lee of Ithaca, Inc., Ithaca, N. Y.

Norton, William C., Norton Electric Co., Ithaca, N. Y.

Sayles, Charles L., Prof., Cornell University, Ithaca, N. Y.

Chicago Section

Member:

Gilman, Brice E., Standard Oil Co., Whiting, Indiana

Associate Members:

Chindlund, Herman J., Samuel R. Lewis & Associates, Chicago, Ill.

Front, Henri S., Sylvania Electric Products, Inc., Chicago, Ill.

Kallevang, Charles J., Curtis Lighting, Inc., Chicago, Ill.

Kralovec, Edward M., Jr., S. R. Lewis & Associates, Chicago, Ill.

Musser, A. R., Central Illinois Electric & Gas Co., Rockford, Ill.

Pollard, Owen W., Central Illinois Electric & Gas Co., Rockford, Ill.

Ross, George W., Sylvania Electric Products, Inc., Chicago, Ill.

Cleveland Section

Members:

Blaisdell, Leonard T., General Electric Co., Cleveland, Ohio

Smedley, C. R., The Glidden Co., Cleveland, Ohio

Associate Members:

Hill, Edwin, Allen Electric Co., Cleveland, Ohio

Kleinsmith, Carlton W., The Bell Electric Co., Cleveland, Ohio

Student Members:

Brampton, Victor E., Case Institute of Technology, East Cleveland, Ohio

Gleiser, Norman B., Case Institute of Technology, Cleveland, Ohio

McCord, Marcus, Case Institute of Technology, Cleveland, Ohio

Neubecker, Thomas Forest, Case Institute of Technology, Cleveland ,Ohio

Oerthel, Robert H., Case Institute of Technology, Cleveland, Ohio

Potieny, Joseph, Case Institute of Technology, Cleveland, Ohio

Connecticut Chapter

Member:

Estler, Kenneth E., Holophane Co., Inc., New York, N. Y.

Associate Members:

Flood, Wm. P., Hill & Harrigan, 37 Whitney Ave., New Haven, Conn.

Myers, John S., Connecticut Light & Power Co., Thompsonville, Conn.

Ober, Richard P., Unadco Mfg. Co., New Haven, Conn.

Procopion, Samson John, Eastern Electric Construction Co., Bridgeport, Conn.

Richards, William E. A., The Connecticut Light & Power Co., Greenwich, Conn.

Domestic Non-Section

Members:

Ellis, George J., General Electric Co., Birmingham, Ala.

Morris, George L., Alabama Power Co., Birmingham, Ala.

Associate Member:

Wiseman, Robert Swern, Mississippi State College, State College, Miss.

Eastern Pennsylvania Chapter

Associate Members:

Austin, Raymond C., Austin Bros., Bethlehem, Pa.

Blackford, W. F., Line Material Co. of Pennsylvania, East Stroudsburg, Pa.

Shollenberger, Howard A., Stony Creek Mills, Pa.

Sprague, C. H., International Correspondence School, Scranton, Pa.

Stover, Jacob R., Pennsylvania Power & Light Co., Sellersville, Pa.

Florida Chapter

Associate Members:

Shields, H. R., General Electric Supply Corp., Miami, Fla.

Sloan, Alfred E., General Electric Supply Corp, Miami, Fla.

Swanson, O. F., Graybar Electric Co., Inc., Miami, Fla.

Pearson, J. T., Westinghouse Electric Supply Co., Miami, Fla.

Pettus, J. A., Graybar Electric Co., Inc., Miami, Fla.

Upson, N. W., Graybar Electric Co., Inc., Miami, Fla.

Foreign Non-Section

Associate Members:

Dawes, Stephen M., British Thompson Houston Co., Ltd., London, England

Egli, Ernst M., Traco Trading Co., Ltd., Zurich, Switzerland

Martelli, Giovanni, Sisma, Via Della Zecca, Bologna, Italy

Wyborn, E. J., Duralite, Ltd., London, England

Georgia Section

Associate Members:

Branham, Robert W., A. Thomas Bradbury, Atlanta, Ga.

Pollard, Thomas V., Walton & Pollard Electric Co., Griffin, Ga.

Rei, Harry D., Sr., Crouse-Hinds Co., Syracuse, N. Y.

Hamilton, Ontario Chapter

Associate Members:

Dynes, John R., Dynes Electric Co., Ltd., Hamilton, Ontario, Canada

Morgan, J. F., Mercury Mills, Ltd., Hamilton, Ontario, Canada

Heart of America Section

Associate Members:

Davis, Wilbert, General Electric Supply Corp., Joplin, Mo.

Erskine, Vincil E., Central Sales Agency, Wichita, Kansas

Everitt, Robert S., Everitt-Bleistein-Associates, Kansas City, Mo.

Iowa Section

Member:

Huntington, Robert A., Iowa Power & Light Co., Des Moines, Iowa

Associate Member:

Merkel, Carence H., Crescent Electric Supply Co., Burlington, Iowa

Michigan Section

Members:

MacFarlane, Harry M., Madison Electric Co., Detroit, Mich.

Ecclestone, John S., S. P. Ecclestone & Sons, Inc., Detroit, Mich.
Hall, Frederick L., Jahr & Lyman, Dearborn, Mich.

MILWAUKEE CHAPTER

Member:

Smythe, Robert L., Line Material Co., Milwaukee, Wis.

Associate Member:

Henningfeld, Don S., Northern Light Co., Milwaukee, Wis.

MONTREAL SECTION

Members:

Lushington, H., Canadian General Electric Co., Ltd., St. John, N. B., Canada
Williamson, W. A., Canadian General Electric Co., Ltd., St. John, N. B., Canada

Associate Members:

Baker, E. W., Shortall Electric Ltd., Montreal, Quebec, Canada
Dennis, R. L., Northern Electric Co., Ltd., Montreal, Quebec, Canada
Doucet, C. J., Canadian Laco Lamps, Ltd., Montreal, Quebec, Canada
Rooney, G. J., H. M. Hopper Co., Ltd., St. John, N. B., Canada
Methe, Marc, Quebec Power Co., Quebec, Que., Canada
Smith, George E., The Webb Electric Co., St. John, N. B., Canada
Tousignant, D. C., Consolidated Paper Corp., Ltd., Port Alfred, Quebec, Canada

Student Member:

Gartshore, J. W., McGill University, Montreal, Quebec, Canada

NEW ENGLAND SECTION

Member:

Meyers, George A., Sylvania Electric Products, Inc., Danvers, Mass.

Associate Members:

Blackburn, Andreas W., Plymouth County Electric Co., Plymouth, Mass.
Davis, Clifford W., Champion Lamp Works, Lynn, Mass.

NEW YORK SECTION

Associate Members:

Field, Walker, Warner-Leeds Co., New York, N. Y.
Lundquist, Oliver, Lundquist Associates, New York, N. Y.
McKee, George H., Jr., G. H. McKee, Inc., Mount Vernon, N. Y.
O'Brien, John P., Herbert G. Martin, Co., Inc., Yonkers, N. Y.
Rattner, Solomon, Cold Cathode Lighting Corp., New York, N. Y.
Sachs, Hyman A., Century Lighting, Inc., New York, N. Y.
Voorhies, D. E., Lamp Dept. General Electric Co., Albany, N. Y.

OHIO VALLEY SECTION

Associate Members:

De Long, Beattie M., The Cincinnati Gas & Electric Co., Cincinnati, Ohio
Dickason, Russell James, University of Cincinnati, Cincinnati, Ohio
Lewis, Frank L., The Miller Co., Meriden, Conn.
Novasic, George, Dayton Power & Light Co., Dayton, Ohio

Student Members:

Albright, Wesley, University of Dayton, Dayton, Ohio
Chong, Albert S. C., University of Dayton, Dayton, Ohio
Clune, Carmel R., University of Dayton, Dayton, Ohio
Groszewski, Daniel J., University of Dayton, Dayton, Ohio
Hentz, Wm. G., University of Cincinnati, Cincinnati, Ohio
Hose, Richard L., Massillon, Ohio
Krause, Manfred, University of Cincinnati, Cincinnati, Ohio
Kroemer, Karl E., Jr., University of Dayton, Dayton, Ohio
Lowry, Neil W., University of Dayton, Dayton, Ohio
Marcel, E. Thomas, University of Cincinnati, Cincinnati, Ohio
Meier, Herbert J., University of Dayton, Dayton, Ohio
Schilmeister, Gordon J., University of Cincinnati, Cincinnati, Ohio
Wheelock, William I., University of Dayton, Dayton, Ohio

PITTSBURGH SECTION

Associate Members:

Goodman, Charles L., Pennsylvania Power Co., New Castle, Pa.
Hooks, Vernon G., Keystone Electrical Supply Co., Butler, Pa.
Wagasky, William E., Acheson Mfg. Co., Braddock, Pa.

ROCKY MOUNTAIN CHAPTER

Members:

Bailey, Lyle M., The Albert Sechrist Mfg. Co., Denver, Colo.
Darger, Stanford P., General Electric Supply Corp., Denver, Colo.

SOUTHERN CALIFORNIA SECTION

Member:

Butler, C. W., Civil Aeronautics Administration, Los Angeles, Calif.

Associate Members:

Helms, Wm. A., Hollywood Wholesale Electric Co., Hollywood, Calif.
Imhof, Erwin J., Manufacturers Marketing Service, Los Angeles, Calif.
Potter, Merle A., Smoot-Holman Co., Inglewood, Calif.
Ryan, Donald P., Dept. of Water & Power, Los Angeles, Calif.

SOUTH TEXAS CHAPTER

Associate Member:

Henry, B. W., Reichardt Electric Co., Houston, Texas

SOUTHWESTERN SECTION

Associate Members:

Bruton, Kenneth L., Southwestern Public Service Co., Amarillo, Texas
Woodall, Eugene C., Marlin Associates, Dallas, Texas

TENNESSEE VALLEY CHAPTER

Member:

Simpson, J. L., Jr., Marr & Holman, Nashville, Tenn.

Associate Member:

Gale, May Love, Tennessee Valley Authority, Electrical Development Branch, Nashville, Tenn.

TORONTO SECTION

Member:

Scott, L. G., Hudson's Bay Co., Winnipeg, Manitoba, Canada

Student Members:

Fancy, W. S., University of Toronto, Toronto, Ontario, Canada
MacPherson, Peter A., University of Toronto, Toronto, Ontario, Canada

UTAH CHAPTER

Associate Member:

Atkins, Livingston E., Jr., Electrical Products Consolidated, Salt Lake City, Utah

WESTERN NEW YORK SECTION

Associate Member:

Abbott, Francis R., Graybar Electric Co., Inc., Buffalo, N. Y.

Current Articles on Lighting

The following list presents titles and source of publication of current articles on lighting and allied subjects which have appeared in recent issues of nationally known magazines having a wide circulation.

"High Quality Lighting—High Working Efficiency," *Electrified Industry*, March, 1949, p. 8

"Sure This Lighting Makes the Work Better," *Electrified Industry*, March, 1949, p. 31

How Wheat Becomes Flour, *Electrified Industry*, March, 1949, p. 50

Lights Aid Cleanliness, *Electrified Industry*, March, 1949, p. 58

"It's Just Like Outside," *Electrified Industry*, March, 1949, p. 64

Colour and Lighting in Factories and on Machines, *Light and Lighting*, January, 1949, p. 136

Planning the Classroom for the Elementary School, by R. Gommel Roessner, *School Board Journal*, March, 1949, p. 37

Gleaming Color for Hope Gas Company's Power Plant, by W. W. Arm-

Continued on page 15A

SUSTAINING MEMBERS

Acme Electric Corp.
Cuba, N. Y. *J. A. Comstock*

Admiral Lamp Manufacturing Corp.
2430 So. Ashland Ave., Chicago, Ill.
F. Schwartz

Advance Transformer Co.
1122 W. Catalpa Ave., Chicago 40, Ill.
Hirsch Epstein

Alabama Power Co.
Birmingham, Ala. *George L. Morris*

All Bright Electric Products Co.
3917-25 N. Kedzie Ave., Chicago 18, Ill.
Max Klein

Amalgamated Electric Corp., Ltd.
384 Pape Ave., Toronto, Ont., Canada
D. W. Patterson

American Concrete Corp.
4727 North Lamon Ave., Chicago 30, Ill.
J. W. Lewis

American Fluorescent Corp.
5407 Broadway, Chicago, Ill. *William Rusnak*

American Sterilizer Co.
Erie, Pa. *Horace Wm. Alexander*

Appleton Electric Co.
1701-1729 Wellington Ave., Chicago 13, Ill.
Nils A. Tornblom

Arkansas Power & Light Co.
Simmons National Bldg., Pine Bluff, Ark.
Max Sudduth

Art Lamp Corp.
1750 W. Fulton St., Chicago 12, Ill.
B. H. Martin

The Art Metal Co.
1814 E. 40th St., Cleveland 3, Ohio
George E. Glatthar

Artistic Lamp Manufacturing Co., Inc.
395 Fourth Ave., New York 16, N. Y.
Myron Perlmutter

Bausch & Lomb Optical Co.
Rochester 2, N. Y. *David L. Williams*

Benjamin Electric Mfg. Co.
Des Plaines, Ill. *John H. Waterbury*

Blue Ridge Glass Corp.
Kingsport, Tenn. *J. H. Lewis*

Board of Water and Electric Light Commissioners
116 W. Ottawa St., P.O. Box 570, Lansing 3, Mich. *John D. Mulnight*

Boston Edison Co.
39 Boylston St., Boston 12, Mass.
R. B. Brown, Jr.

Bright Light Reflector Co., Inc.
Fairfield & State, Bridgeport 5, Conn.
C. E. Scholl

Brockton Edison Co.
36 Main St., Brockton 67, Mass.
W. A. Forbush

Buffalo Niagara Elec. Corp.
Buffalo 3, N. Y. *Jack F. Parsons*

Edward F. Caldwell & Co., Inc.
101 Park Ave., New York 17, N. Y.
E. T. Caldwell

California Electric Power Co.
P.O. Box 512, Riverside, Calif.
W. S. Fleming

Cal-Lite, Inc.
12600 S. Yukon Ave., Hawthorne, Calif.
N. L. Ureles

Calpa Products Co.
4116 Chester Ave., Philadelphia 4, Pa.
Paul C. Calisi

Cambridge Electric Light Co.
46 Blackstone St., Cambridge 39, Mass.
Reginald H. Bowman

Canadian General Elec. Co., Ltd.
212 King St., Toronto, Ont. *R. M. Love*

Canadian Laco Lamps, Ltd.
745 Guy St., Montreal, Que. *J. Thomas*

Canadian Line Materials, Ltd.
Postal Station H, Toronto 13, Ont., Canada
L. E. Messinger

Central Hudson Gas and Elec. Corp.
50 Market St., Poughkeepsie, N. Y.
H. E. Dexter

Central Illinois Light Co.
316 Jefferson Ave. S., Peoria 2, Ill.
R. K. Dallas

Central Illinois Public Service Co.
607 E. Adams St., Springfield, Ill. *B. L. Palm*

Central Maine Power Co.
9 Green St., Augusta, Maine *Roland W. Hess*

Central New York Power Corp.
300 Erie Boulevard W., Syracuse, N. Y.
L. D. McCormac

Central Power & Light Co.
P.O. Box 2121, Corpus Christi, Texas
James M. Williams

Champion Lamp Works Div. of Consolidated Electric Lamp Co.
600 Broad St., Lynn, Mass. *Ellery H. Raddin*

Chicago Miniature Lamp Works
1500 North Ogden, Chicago, Ill.
Edward M. Pollock

Cincinnati Gas & Electric Co.
Fourth & Main Sts., Cincinnati 1, Ohio
J. R. Hartman

Circlite Corp.
118 So. Clinton St., Chicago, Ill.
George Gumberg

City of Burbank, California Public Service Department
174 W. Magnolia Boulevard, Burbank, Calif.
J. H. McCambridge

City of Glendale Public Service Dept.
119 N. Glendale Ave., Glendale 6, Calif.
P. Diederich

City of Riverside Electric Light Dept.
3854 Mulberry St., Riverside, Calif.
L. W. Grayson

City of Seattle, Dept. of Lighting — Puget Sound
1015 Third Ave., Seattle 4, Wash.
P. C. Spowart

Colonial Electric Products Co., Inc.
1-115 Market St., E. Paterson, N. J.
Wallace M. Woodworth

Colonial Premier Co.
466 W. Superior St., Chicago 10, Ill.
Richard Weis

Commercial Light Co.
841 W. Washington Blvd., Chicago, Ill.
Michael R. Fine

Commonwealth Edison Co.
72 W. Adams St., Chicago 90, Ill.
Ralph G. Raymond

The Connecticut Light & Power Co.
250 Freight St., Waterbury 91, Conn.

Conowingo Power Co.
118 North St., Elkton, Md. *A. E. Granger*

Consolidated Edison Co. of N. Y., Inc.
4 Irving Place, New York 3, N. Y.
Clarence Law

Consolidated Gas, Elec. Light & Power Co. of Baltimore
100 W. Lexington St., Baltimore 1, Md.
E. H. Tillman

Consumers Power Co.
212 Michigan Ave. W., Jackson, Mich.
D. E. Karn

Consumers Public Power Co.
1452-25th Ave., Columbus, Nebraska
W. H. Sinke

Corning Glass Works
Corning, N. Y. *A. S. Tylor*

Coyne Electrical School, Inc.
500 So. Paulina St., Chicago 7, Ill.
John Hanan

Crescent Electric Supply Co.
765 Iowa St., Dubuque, Iowa
Titus B. Schmid

Crouse-Hinds Co.
Syracuse 1, N. Y. *A. H. Clarke*

Crouse Hinds Co. of Canada, Ltd.
7 Labatt Ave., Toronto, Ont. *F. R. Jeffery*

Curtis Lighting, Inc.
6135 W. 65th St., Clearing Station, Chicago 38, Ill. *Darwin Curtis*

Curtis Lighting of Canada, Ltd.
195 Wicksteed Ave., Leaside, Toronto 12, Ont. *H. L. Wright*

Cutler Light Manufacturing Co.
2026-28 N. 22d St., Philadelphia 21, Pa.
Robert T. Cutler

Dallas Power & Light Co.
1506 Commerce St., Dallas 1, Texas
W. G. Moore

Day-Brite Lighting, Inc.
5401 Bulwer St., St. Louis 7, Mo.
D. J. Biller

The Dayton Power & Light Co.
25 No. Main St., Dayton, Ohio
H. S. Nonneman

Dazor Manufacturing Corp.
4483 Duncan Ave., St. Louis 10, Mo.
P. L. Read

Delaware Power & Light Co.
600 Market St., Wilmington 99, Del.
W. A. F. Pyle

Dept. of Water & Power, City of Los Angeles, Bur. of Power & Light
Box 3669 Terminal Annex, 207 So. Broadway, Los Angeles 54, Calif. *C. P. Garman*

Detroit Edison Co.
2000 Second Ave., Detroit 26, Mich.
L. E. Tayler

Detroit Steel Products Co.
2250 E. Grand Blvd., Detroit 11, Mich.
W. Clifton Randall

Dobkin Electrical Supply Co.
329 W. Madison St., Chicago, Ill.
Jerry Dobkin

E. I. duPont de Nemours & Co., Inc. (Fabrics & Finishes Div.)
Wilmington 98, Del. *S. W. Quisenberry*

Duquesne Light Co.
435 Sixth Ave., Pittsburgh 19, Pa.
G. W. Ousler

Duro Test Corp.
2321 Hudson Blvd., North Bergen, N. J.
James L. Cox

Eastern Fixture Co., Inc.
170 Vernon St., Boston 20, Mass.
Louis Gilman

East Side Metal Spinning & Stamping Corp.
1 W. 34th St., New York 1, N. Y.
M. A. Kremer

Ebasco Services, Inc.
2 Rector St., New York 6, N. Y.
W. E. Parrott

Efengee Electrical Supply Co.
671 W. Washington St., Chicago 6, Ill.
Louis Coleman

Electrical Information Publications, Inc.
20 E. Mifflin, P.O. Box 232, Madison, Wis.
W. N. Dudley

Electrical Testing Laboratories, Inc.
79th St. & East End Ave., New York City 21, N. Y. *Preston S. Millar*

Elec. Service Mfg. Co.
17th & Cambria Sts., Philadelphia 32, Pa.
E. A. Leinroth

Electric Supply Corp.
701 W. Jackson Blvd., Chicago 6, Ill.
L. B. Mangione

(*Note:* Names of Official Representatives appear in Italics)

Electro Manufacturing Corp.
2000 W. Fulton St., Chicago 12, Ill.
L. K. Schoenbrod

Electrolier Mfg. Company, Ltd.
5849 Boyer St., Montreal, Que., Canada.
John Issenman

Ender Manufacturing Corp.
260 West St., New York 13, N. Y.
Jules Levenstein

Englewood Electrical Supply Co.
5801-03 So. Halsted St., Chicago, Ill.
Ray O'Leary

Famous Fluorescent Light Co.
762 N. Ogden Ave., Chicago 22, Ill.
Jack E. Stone

Federal Electric Company, Inc.
8700 S. State St., Chicago, Ill.
John H. Gochat

Fitchburg Gas & Electric Light Co.
537 Main St., Fitchburg, Mass. *A. G. Neal*

Fluorescent Equipment & Mfg. Co.
2570 Superior Ave., Cleveland 14, Ohio
Leonard S. Freeman

Fluorescent Maintenance Co., Inc.
1480 S. Robertson Blvd., Los Angeles 35, Calif. *Leonard K. Black*

Fluores-O-Lite Co.
Evans Terminal, No. Broad St., Hillside, N. J.
Meyer H. Silverman

The Fostoria Pressed Steel Corp.
Fostoria, Ohio *E. L. Bates*

H. A. Framburg & Co.
3320-28 Carroll Ave., Chicago 24, Ill.
Stanley A. Framburg

The France Mfg. Co.
10325 Berea Rd., Cleveland 2, Ohio
J. B. Mayne

The Frankelite Co.
1425 Rockwell Ave., Cleveland 14, Ohio
Dave Frankel

Franklin Design Service, Division of Safeway Stores, Inc.
4th & Jackson Sts., P.O. Box 660, Oakland 4, Calif. *H. J. Dutton*

The Frink Corporation
27-01 Bridge Plaza North, Long Island City, N. Y. *Theo. J. Brassel, Jr.*

Gallagher-O'Brien Electric Co., Inc.
712 N. State St., Chicago 10, Ill.
Frank A. Gallagher

Garden City Plating & Mfg. Co.
1750 No. Ashland Ave., Chicago 22, Ill.
G. G. Harney

General Electric Co., Apparatus Dept.
Schenectady 5, N. Y. *A. F. Dickerson*

General Electric Co., Lamp Dept.
Nela Park, Cleveland 12, Ohio
Willard C. Brown

General Electric Supply Corp.
1260 Boston Ave., Bridgeport, Conn.
W. W. Booth

General Lighting Products Co.
16 Delancy St., Newark 5, N. J.
Nathan H. Eglowstein

General Outdoor Advertising Co., Inc.
515 So. Loomis St., Chicago, Ill. *R. E. Nevins*

The Georgia Power Co.
Electric Building, Atlanta 1, Ga.
Charles A. Collier

Gibson Manufacturing Co.
1919 Piedmont Circle, N. E., Atlanta, Ga.
E. R. Gibson

Gill Glass & Fixture Co.
Amber & Tioga Sts., Philadelphia 34, Pa.
F. D. Gill

Gillinder Brothers, Inc.
Erie & Liberty Sts., Port Jervis, N. Y.
J. Fletcher Gillinder

Gleason-Tiebout Glass Co.
99 Commercial St., Brooklyn 22, N. Y.
Charles W. Gleason

Globe Lighting Products Co., Inc.
397 Seventh Ave., Brooklyn, N. Y.
Isidor Rosenblatt

Golde Manufacturing Co.
1214 West Madison, Chicago 7, Ill.
E. W. Goldberg

Grand Rapids Store Equip. Co.
1340 Monroe Ave., N. W., Grand Rapids 2, Mich. *Kenneth C. Welch*

Graybar Electric Co., Inc.
420 Lexington Ave., New York 17, N. Y.
Raymond C. Kinney

Gulf States Utilities Co.
Box 2951, Beaumont, Texas *Clarence Barron*

The Edwin F. Guth Co.
2615 Washington Ave., St. Louis 3, Mo.
Fred E. Guth

Hartford Electric Light Co.
266 Pearl St., Hartford 3, Conn.
Victor Ouellette

Hawkins Electric Co.
1447 Washington Blvd., Chicago 7, Ill.
R. R. Hill

A. Ward Hendrickson & Co., Inc.
45-17 Pearson St., Long Island City 1, N. Y.
Joseph T. Manuccia

Holdenline Co.
2301 Scranton Rd., Cleveland 13, Ohio
H. E. Ingraham

Holophane Company, Inc.
342 Madison Ave., New York 17, N. Y.
H. L. Logan

Houston Lighting & Power Co.
P.O. Box 1700, Houston 1, Texas
H. O. Clarke

Hydro-Electric Power Comm. of Ont.
620 University Ave., Toronto, Ontario
R. L. Hearn

Hyland Electrical Supply Co.
700 West Jackson Blvd., Chicago, Ill.
Chas. H. Weiermann

Illinois Power Co.
134 East Main St., (L Box 511 B), Decatur 70, Ill. *Allen Van Wyck*

Illuminating Engineering Co.
2347 E. Nine Mile Road, Hazel Park, Mich.
Bert C. Pretzer

Iowa-Illinois Gas & Electric Co.
United Light Bldg., Davenport, Iowa
John M. Hollingsworth

Iowa Public Service Co.
400 Commercial St., Waterloo, Iowa
C. R. Wagoner

Jeannette Shade & Novelty Co.
N. Fourth St., Jeannette, Pa. *H. N. Crock*

Jefferson Electric Co.
Bellwood, Ill. *L. Maurer*

Jersey Central Power & Light Co.
501 Grand Ave., Asbury Park, N. J.
Thomas R. Dobson

Joleco Corporation
2513 Baldwin St., St. Louis, Mo.
George Ledbetter

Jones Metal Products Co.
West Lafayette, Ohio *H. Boyer*

Joslyn Mfg. & Supply Co.
3700 So. Morgan St., Chicago 9, Ill.
J. H. Fahey

Kahn Manufacturing Co., Inc.
2051 N. 19th St., Milwaukee, Wis.
Charles F. Kahn

Kansas City Power & Light Co.
P.O. Box 679, Kansas City 10, Mo.
John M. Arthur, Jr.

Kansas Gas & Electric Co.
P.O. Box 204, Wichita, Kans. *H. W. Hobson*

The Kawneer Co.
North Front St., Niles, Mich.
Richard M. Spray

The Kayline Company
2480 E. 22nd St., Cleveland 15, Ohio
M. A. Eskins

Kelso-Burnett Electric Co.
223 W. Jackson Blvd., Chicago 6, Ill.
Sigmund A. Hollinger

Keystone Electric Manufacturing Co.
2228-36 E. Tioga St., Philadelphia 34, Pa.
Leonard M. Siegel

The Kirlin Company
3435 E. Jefferson Ave., Detroit 7, Mich.
Ivan Kirlin

Kopp Glass, Inc.
Swissvale, Pa. *P. C. Ashe*

Kubec Electric Co.
630 W. Jackson Blvd., Chicago 6, Ill.
Fred A. Girten

The La Salle Lighting Products, Inc.
145 Seneca St., Buffalo 3, N. Y.
Nelson R. Zicherman

Leader Electric Manufacturing Corp.
3500 N. Kedzie St., Chicago 18, Ill.
Walter Glass

The Leeds & Northrup Co.
4901 Stenton Ave., Philadelphia 44, Pa.
I. M. Stein

The Leland Electric Co.
1501 Webster St., Dayton, Ohio
Harold A. Cline

Libbey Owens Ford Glass Co., Plaskon Division
2112-24 Sylvan Ave., Toledo, Ohio
Dr. M. H. Bigelow

Light Control Company
3217 Casitas Ave., Los Angeles 26, Calif.
Stanley E. Lindahl

Lighting & Lamps
114 East 32nd St., New York 16, N. Y.
James Krieger

Lighting Incorporated
1834 So. Figueroa St., Los Angeles, Calif.
Harry Marsh

Lighting Products, Inc.
2259 W. Park Ave., Highland Park, Ill.
D. E. Dunno

Lightolier Co.
11 East 36th St., New York 16, N. Y.
H. Stollnitz

Line Material Co.
800 North 8th St., Milwaukee 1, Wis.
M. C. Harsh

Litecontrol Corp.
36 Pleasant St., Watertown 72, Mass.
Paul H. Lamson

Louisiana Power & Light Co.
142 Delaronde St., Station "A," New Orleans, La. *C. L. Osterberger*

Lumidor Mfg. Co. Inc.
4801 E. 50th St., Los Angeles 11, Calif.
Arthur N. Nielsen

Luminator, Inc.
120 N. Peoria St., Chicago 7, Ill.
Albert L. Arenberg

T. R. Lyda Manufacturers Rep.
4922 Washington Blvd., Indianapolis, Ind.
T. R. Lyda

Lynn Gas & Electric Co.
90 Exchange St., Lynn, Mass. *James A. Cook*

Macbeth Corp.
227 West 17th St., New York, N. Y.
Norman Macbeth

Malden Electric Co.
157 Pleasant St., Malden, Mass.
Donald S. Bennett

Markel Electric Products, Inc.
145 E. Seneca St., Buffalo 3, N. Y.
D. L. Ripley

Markstone Manufacturing Co.
1917 N. Springfield Ave., Chicago 47, Ill.
M. J. Marks

La Cie Martineau Electrique Ltee.
24 rue du Roi, Quebec, Canada
Henri Martineau

Metalcraft Products Company
306-08 Cherry St., Philadelphia 6, Pa.
Alex Abel

Metal Window Institute
Cheltenham, Pa. *George Hingston*

Metropolitan Edison Co.
412 Washington St., Reading, Pa.
E. J. Ingram

Metropolitan Electrical Supply Co.
20 N. Jefferson St., Chicago 6, Ill.
H. J. Privat

Midwest Chandelier Co.
15th & Gentry Sts., No. Kansas City 16, Mo.
Sidney Lefkovitz

The Miller Co.
Meriden, Conn. *G. W. Beals*

Mississippi Glass Co.
220 Fifth Ave., New York City 1, N. Y.
E. H. Hobbie

Mississippi Power Co.
Gulfport, Miss. *R. M. Shearer*

Mississippi Power & Light Co.
Lampton Building, Jackson 113, Miss.
Henry B. Sargent

Mitchell Manufacturing Co.
2525 Clybourn Ave., Chicago 14, Ill.
Bernard Mitchell

Mobilite Inc.
440 Mercer St., Jersey City, N. J.
Sidney Solmor

Modern Light Co.
1512 Pine St., St. Louis 3, Mo.
Karl L. Rundberg

Modern Light & Equip. Co.
3812 S. Wabash Ave., Chicago, Ill.
M. L. Offenberg

Moe-Bridges Corp.
1415 Illinois Ave., Sheboygan, Wis.
J. G. Rainey

Montana-Dakota Utilities Co.
831 Second Ave. So., Minneapolis 2, Minn.
W. L. Hayes

Municipal Light and Power Dept.
City of Pasadena, California, 302 City Hall,
Pasadena 1, Calif. *E. L. Bettannier*

Mutual Sunset Lamp Mfg. Co., Inc.
540 Empire State Bldg., New York 1, N. Y.
Morris Thau

The Narragansett Electric Co.
49 Westminster St., Providence 1, R. I.
C. R. Broadhead

National Chemical & Manufacturing Co. Luminall Paint Div.
3617 So. May St., Chicago 9, Ill.
John Marshall Zir

National Lighting Products
4221 W. Harrison St., Chicago 24, Ill.
D. J. Epp

Nebraska Power Co.
720 Electric Bldg., Omaha 2, Neb.
G. A. Walker

Nelson-Tombacher Co.
81 Prospect St., Brooklyn, N. Y.
M. J. Tombacher

New Bedford Gas & Edison Light Co.
693 Purchase St., New Bedford, Mass
W. S. Fenstermacher

New Orleans Public Service, Inc.
317 Baronne St., New Orleans, La.
S. L. Drumm

New York Power & Light Corp.
Albany 1, N. Y. *Coburn D. Hollister*

Northern Electric Co. Ltd.
1620 Notre Dame St., West, Montreal, Quebec.
F. P. Labey

Northern Indiana Public Service Co. Gary Div.
500 Broadway, Gary, Ind. *J. C. Suckman*

Northern States Power Co.
Minneapolis 2, Minn. *Carl T. Bremicker*

Ohio Edison Co. (Akron Div.)
Akron 8, Ohio *R. F. Hartenstein*

The Ohio Power Co.
301-315 Cleveland Ave., S. W., Canton 2, Ohio
C. B. Morin

The Ohio Public Service Co.
P.O. Box 6058, Cleveland 1, Ohio.
C. L. Dunn

Oklahoma Gas & Electric Co.
Box 1498, Oklahoma City 1, Okla.
E. W. Gray

Omaha Public Power District
720 Electric Bldg., Omaha 2, Nebraska
E. E. Schwalm

Overbagh & Ayres Mfg. Co.
411 S. Clinton St., Chicago 77, Ill.
Alfred A. Overbagh

Pacific Gas & Electric Co.
245 Market St., San Francisco 5, Calif.
O. E. Doerr

Pacific Power & Light Co.
522 Public Service Bldg., Portland 4, Oregon
C. A. Root

Peerless Electric Ltd.
1090 Pratt Ave., Outremont, Quebec.
L. A. Van Duzer

Wm. Penn Fluorescent Light Mfg. Co.
1639 So. Broad St., Philadelphia, Pa.
William Ranieri

Pennsylvania Electric Co.
535 Vine St., Johnstown, Pa.
Frank R. Knowles

Pennsylvania Power Co.
19 E. Washington St., New Castle, Pa.
P. G. Dingledy

Pennsylvania Power & Light Co.
901 Hamilton St., Allentown, Pa.
J. M. Stedman

Pennsylvania Wire Glass Co.
1612 Market St., Philadelphia 3, Pa.
Dr. Frank W. Preston

The Perfeclite Company
1457 E. 40th St., Cleveland, Ohio
Joseph L. Jaffe, Jr.

Philadelphia Electric Co.
1000 Chestnut St., Philadelphia 5, Pa.
H. B. Bryans

Philadelphia Electrical & Mfg. Co.
1228 North 31st St., Philadelphia 21, Pa.
H. L. Weid

Phoenix Glass Co.
Monaca, Pa. *D. G. Cameron*

Pierce Electric Co.
367 West Adams St., Chicago 6, Ill.
John H. Pierce

Pittsburgh Plate Glass Co.
Grant Bldg., Pittsburgh 19, Pa.
R. B. Tucker

Pittsburgh Reflector Co.
403-411 Oliver Bldg., Pittsburgh 22, Pa.
H. C. Zimmeister

Polaroid Corp.
730 Main St., Cambridge, Mass.
Walter Lown

Portland General Electric Co.
Electric Bldg., Portland 5, Ore. *T. W. Fitch*

The Potomac Edison Co.
55 E. Washington St., Hagerstown, Md.
S. S. Bradford

Public Service Co. of Colo.
900 Fifteenth St., Denver, Colo. *G. B. Buck*

Public Service Co. of Indiana, Inc.
110 N. Illinois St., Indianapolis 9, Ind.
G. O. Stewart

Public Service Co. of Northern Illinois
72 West Adams St., Chicago 3, Ill.
G. K. Hardacre

Public Service Co. of Oklahoma
Box 201, Tulsa 2, Okla. *C. N. Robinson*

Public Service Electric & Gas Co.
80 Park Place, Newark 2, N. J.
H. P. J. Steinmetz

Puget Sound Power & Light Co.
860 Stuart Bldg., Seattle 11, Wash.
Frank McLaughlin

The Pyle-National Co.
1334 N. Kostner Ave., Chicago 51, Ill.
T. E. McDowell

Quadrangle Mfg. Co.
32 So. Peoria St., Chicago 7, Ill.
Dwight E. Worrell

Quebec Hydro-Electric Commission
107 Craig St., West, Montreal, Que.
Paul E. Poitras

Quebec Power Co.
229 St. Joseph St., Quebec, Que.
Jean Saint-Jacques

Rambusch Decorating Co.
40 W. 13th St., New York 11, N. Y.
Edward Rambusch

Revere Electric Mfg. Co.
6009-17 N. Broadway, Chicago 40, Ill.
Van N. Marker

Revere Electric Supply Co.
757 West Jackson Blvd., Chicago, Ill.
Floyd Fernau

Ritter Co., Inc.
400 West Ave., Rochester 11, N. Y.
Gordon E. Cameron

Rochester Gas & Electric Corp.
89 East Ave., Rochester 4, N. Y.
Frank C. Taylor

Rockland Light & Power Co.
Nyack, N. Y. *D. S. Schaab*

Rohm and Haas Co.
222 W. Washington Sq., Philadelphia 5, Pa.
F. W. Tetzlaf

Ruby Lighting Corp. of California
1212 So. Olive St., Los Angeles, Calif.
Ben Ruby

Ruby-Phillie Corp.
32-02 Queens Blvd., Long Island City 1, N. Y.
Louis Phillips

Rumsey Electric Co.
1007 Arch St., Philadelphia 7, Pa.
T. W. Lauer

Ryall Electric Supply Co.
1160 Stout, Denver, Colo. *C. O. Ryall*

S & M Lamp Co.
119 West 36th Place, Los Angeles 54, Calif.
Jim Shirreffs

The Safety Car Heating & Lighting Co.
P.O. Box 904, New Haven 4, Conn.
Leonard Pierson

St. Joseph Ry., Light, Heat & Power Co.
520 Francis St., St. Joseph 2, Mo.
F. P. O'Connor

Sandee Manufacturing Co.
5050 Foster Ave., Chicago, Ill.
Co-tes N. Sprankle

Sandel Manufacturing Co.
3618 So. Loomis Place, Chicago 9, Ill.
A. L. Sandel

San Diego Gas & Electric Co.
P.O. Box 1831, San Diego 12, Calif.
A. E. Holloway

Savannah Electric & Power Co.
Savannah, Ga. *J. L. Davidson*

Schockett Electric Co.
1061 Broadway St., Denver 3, Colo.
Carl Schranz, Jr.

Schomer Electric Supply
164 S. Broadway, Aurora, Ill.
Daniel Schomer

The Scott-Jaqua Co. Inc.
316 Indiana Terminal Warehouse Bldg., Indianapolis, Ind. *C. A. Jaqua*

The Albert Sechrist Mfg. Co.
1717 Logan St., Denver 5, Colo.
K. L. Francis

L. J. Segil Co.
2500 W. North Ave., Chicago, Ill.
Louis Rosenstein

Shawinigan Water and Power Co.
600 Dorchester St., W., Montreal, Que.
J. K. Wilson

The Sherwin-Williams Co.
101 Prospect Ave., N. W., Cleveland 1, Ohio
J. A. Meacham

The Sight Light Corp.
P.O. Drawer C, Deep River, Conn.
E. L. Canfield

Silvray Lighting, Inc.
R. K. O. Bldg., Radio City, New York 20, N. Y. *J. M. Gilbert*

Sioux City Gas & Electric Co.
515 Fifth St., Sioux City 4, Iowa *C. R. Tracy*

A. L. Smith Iron Co.
217 Everett Ave., Chelsea, Mass.
Joseph Fishman

Smoot-Holman Co.
321 No. Eucalyptus Ave., Inglewood, Calif.
L. A. Hobbs

Sola Electric Co.
4633 W. 16th St., Chicago 50, Ill.
L. C. Marschall

Solar Light Mfg. Co.
1357 S. Jefferson St., Chicago 7, Ill.
A. Lazerson

The Solex Co. Ltd.
280 Faillon St., West, Montreal, Que.
Leon Beauchamp

Southern Calif. Edison Co., Ltd.
601 West 5th St., Los Angeles 53, Calif.
G. M. Rankin

Southern Canada Power Co. Ltd.
355 James St., West, Montreal, Que.
George E. Atchinson

Southern Colorado Power Co.
Box 75, Pueblo, Colo.
G. W. Milliken

Southern Indiana Gas & Elec. Co.
P.O. Box 569, Evansville 3, Ind.
C. K. Graham

Southern Lighting Mfg. Co.
P.O. Box 2546, Orlando, Fla.
Max K. Aulick

Southwestern Gas & Elec. Co.
Box 1106, Shreveport, La.
J. E. Elliott

Southwestern Public Service Co.
Amarillo, Texas
J. E. Cunningham

Sperti Electric Mfg. Corp.
Beech & Kenilworth Aves., Norwood, Ohio
Ralph A. Lastro

The Spero Electrical Corp.
18222 Lanken Ave., Cleveland, Ohio
Herbert I. Spero

Stanley Electric Mfg. Co.
1234 Carpenter St., Philadelphia 47, Pa.
Bernard S. Heller

Steber Manufacturing Co.
2700 Roosevelt Rd., Broadview, Maywood, Ill.
T. L. D. Lynzweiler

Steiner Electric Co.
3500 Milwaukee Ave., Chicago 41, Ill.
George S. Steiner

Sterling Reflector & Mfg. Co.
3249 West Grand Ave., Chicago 51, Ill.
Anton Oberkuber

Sunbeam Lighting Co.
777 E. 14th Place, Los Angeles 11, Calif.
Herbert L. Krieger

Sun-Ray Fluorescent Co.
600 South Michigan Ave., Chicago, Ill.
Jerome Gimbel

Sylvania Electric Products, Inc.
500 5th Ave., New York, N. Y.
D. P. Caverly

Tampa Electric Co.
Cass & Tampa Sts., Tampa 1, Fl.
F. J. Gannon

Texas Electric Service Co.
Electric Bldg., Fort Worth 1, Texas
R. E. Hendricks

Thompson Electric Co.
1101 Power Ave. N. E., Cleveland 14, Ohio
Thayer B. Farrington

Toledo Edison Co.
Edison Bldg., Toledo 4, Ohio
Charles A. Harrison

Toronto Hydro-Electric System
14 Carlton St., Toronto 2, Ont.
A. W. J. Stewart

Torstenson Glass Co.
3233 N. Sheffield Ave., Chicago 13, Ill.
Elmer L. Torstenson

Triangle Industries
600 W. Adams St., Chicago, Ill.
Leonard Cohen

Tru-Lite Ltd.
824 Notre Dame St., W., Montreal, Que.
Omer M. Trudel

Underwriters' Laboratories, Inc.
207 E. Ohio St., Chicago 11, Ill.
Ferd. Neumer

Union Electric Co. of Missouri
12th & Locust Sts., St. Louis 1, Mo.
W. L. Berry

Union Metal Mfg. Co.
Canton 5, Ohio
W. A. Porterfield

The United Illuminating Co.
80 Temple St., New Haven 6, Conn.
E. B. Haskell

United Manufacturing Co.
Div. United Advertising Corp.
190 Whalley Ave., New Haven, Conn.
William R. Harris

Utah Power & Light Co.
Box 899, Salt Lake City 10, Utah
W. A. Huckins

Verd-A-Ray Corp.
615 Front St., Toledo 5, Ohio
O. S. Levi

John C. Virden Co.
6009-6103 Longfellow Ave., Cleveland 3, Ohio
W. G. Sawyer

John C. Virden, Ltd.
55 Front St., East, Toronto, Ont.
P. G. Kirkpatrick

Virginia Electric & Power Co.
Richmond, Va.
J. G. Holtzclaw

Voigt Co.
1649 No. Broad St., Philadelphia 22, Pa.
C. J. Frank

The F. W. Wakefield Brass Co.
Vermilion, Ohio
A. F. Wakefield

The Washington Water Power Co.
P.O. Drawer 1445, Spokane 6, Wash.
Carl L. Hofman

The Watson Standard Co.
225 Galveston Ave., Pittsburgh 12, Pa.
J. V. Farland

The Welsbach Corp.
1500 Walnut St., Philadelphia 2, Pa.
H. H. Adams

Westchester Lighting Co.
9 South 1st Ave., Mt. Vernon, N. Y.

Westinghouse Electric Corp.
1216 W. 58th St., Cleveland 2, Ohio (P.O. Box 5817)
W. F. White

Westinghouse Electric Supply Co.
113 North May St., Chicago 7, Ill.
Henry Czech

Westinghouse Lamp Div.
Bloomfield, N. J.
Samuel G. Hibben

West Penn Power Co.
14 Wood St., Pittsburgh 30, Pa.
Harry Restofski

The Wheeler Insulated Wire Co., Inc.
150 E. Aurora St., Waterbury 91, Conn.
George B. Horn

Wheeler Reflector Co.
275 Congress St., Boston 10, Mass.
K. A. Sawin

Wiedenback-Brown Co., Inc.
111 Eighth Ave., New York 11, N. Y.
W. C. Stockberger

R. & W. Wiley, Inc.
119 Dearborn St., Buffalo 7, N. Y.
H. B. Alderman

H. E. Williams Products Co.
108 S. Main St., Carthage, Mo.
F. B. Williams, Jr.

Wilmot Castle Co.
1255 University Ave., Rochester 7, N. Y.
E. H. Greppin

J. A. Wilson Lighting & Display Ltd.
9 Morrison St., Toronto, Ont.
J. A. Wilson

The Windsor Utilities Comm., Hydro Div.
149 Chatham St., W., Windsor, Ont.
W. A. Shaw

The Wiremold Company
Hartford 10, Conn.
D. Hayes Murphy

Wisconsin Electric Power Co.
Public Service Bldg., Milwaukee 1, Wis.
G. W. Van Derzee

Wisconsin Gas & Elec. Co.
100 Third St., Racine, Wis.
J. H. Dunham

Wisconsin Power & Light Co.
122 W. Washington Ave., Madison 1, Wis.
J. D. Howard

Wisconsin Public Service Corp.
Green Bay, Wis.
A. G. Bur

Worcester County Electric Co.
11 Foster St., Worcester, Mass.
Fred E. Littlefield

Yonkers Electric Light & Power Co.
9 South 1st Ave., Mt. Vernon, N. Y.

THREE DISTINCTIVE PITTSBURGH PERMAFLECTOR FLUORESCENT LUMINAIRES combine maximum lumen output and minimum brightness ratios with economical initial cost and low installation cost.

All three "Monroe" Units give both downward and upward light distribution and have 35° crosswise and 25° lengthwise shielding. "Quick release" fittings allow hinging of the baffle-bottom from either side or complete assembly removal. Knockouts permit any type of installation. Adjustable hangers are available for individual or end-to-end pendant mounting.

"The Monroe" 2-Lamp Luminaires are typical of Pittsburgh Permaflector Quality Lighting Equipment designed for efficient performance, easy installation and simple maintenance. Before you buy or specify—check the many advantages of *Planned Lighting with Pittsburgh Permaflector Fluorescent and Incandescent Units.*

CONDENSED DATA ON "*The Monroe*"

A-5240-PL LUMINAIRE*—White translucent plastic side-panels are firmly secured in a one-piece, stamped steel; baked-on white enamel baffle-louvers and reflector. Efficiency —81%.

A-5240-AL LUMINAIRE*—Aluminum side-panels and transverse louvers distinguish this unit. Side-panels are longitudinally embossed for added appearance and strength. Efficiency —78%.

A-5240-ST LUMINAIRE*—Entire unit is 20 gauge sheet-steel. Transverse louvers and longitudinal reflectors are baked-on white enamel. Embossed side-panels are baked-on metallic silver-finish. Efficiency —83%.

Die-formed, metal parts assure precision fit, maximum rigidity and strength. One-piece construction with open bottom allows ready access to wiring channels from below when installing the luminaires. Medallion silhouettes of President Monroe, superimposed over cross-quills, add a decorative note to the ends and conceal knockouts used for continuous-runs.

For Full Details on "The Monroe"

Send for Advance Notice Sheet A-7. For information on other Fluorescent or Incandescent Equipment, request Catalogs 48 and 46 on your letterhead.

*Patent Pending

"Pennsbury" Permaflector

Pittsburgh Reflector Company

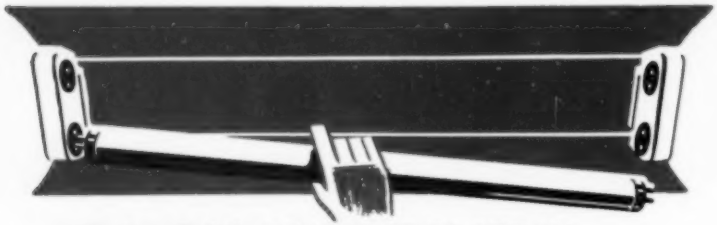
411 OLIVER BUILDING • PITTSBURGH 22, PENNSYLVANIA

MANUFACTURERS OF FLUORESCENT & INCANDESCENT LIGHTING EQUIPMENT

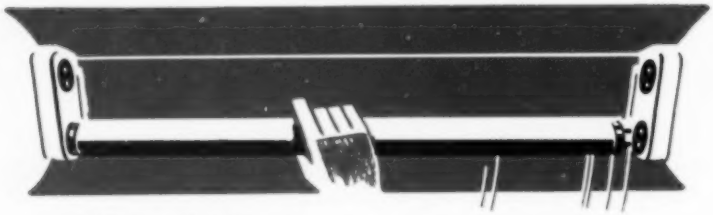
Permaflector Lighting Engineers in All Principal Cities

PITTSBURGH PERMAFLECTOR LIGHTING EQUIPMENT IS DISTRIBUTED BY BETTER ELECTRICAL WHOLESALERS EVERYWHERE

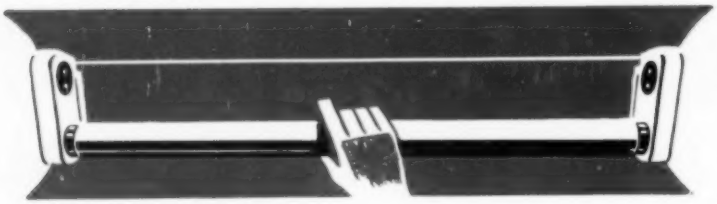
Build more "SELL" into your product with G-E Components



PUSH CONTACT PLATE IN
(A SLIGHT TWIST SEATS LAMP PINS)



SWING FREE END OF LAMP UP



POP! IT'S FIRMLY IN

Re-lamping G-E Turret* fluorescent lampholders is as easy as that. No need to fit the lamp accurately in place. No gadgets to hold the lamp firm. Turret lampholders actually make re-lamping a one-hand job.

This easy-maintenance story can be a real sales help to you. Manufacturers now using G-E Turret lampholders have found them effective in making sales—many more are turning to Turrets as the ideal fluorescent lampholder.

In addition to their sales appeal, you'll find Turrets are built to speed fixture assembly. They mount easily on any flat surface—terminal holes are marked for positive identification—and starter sockets are built in. (Turrets are made for two- or three-lamp fixtures.) For more information, contact the G-E accessory equipment representative in your area, or write to Section Q35-487, Construction Materials Department, General Electric Company, Bridgeport 2, Connecticut.

*Trade-mark Reg. U. S. Pat. Off.

GENERAL ELECTRIC

YOUR FIXTURES will keep customers happy long after installation, if you equip them with General Electric Watch Dog* starters. Watch Dogs are the starters that stop lamps cold when they begin to blink. They cut out the annoyance of flickering lamps—prolong starter and ballast life. Watch Dogs can be reset easily by merely pushing a button.

SWITCHES—Turn-type manual starting fluorescent switches are part of the complete General Electric line. They are available with coded leads attached, for easy wiring and assembly. Switches are another point in your sales story of "General Electric all the way through, from power cord to lampholder."

CIRCLINE LAMPHOLDERS—To give you complete design flexibility on Circline fixtures, General Electric offers you two types of lampholders. The channel type includes two-point mounting complete with starter switch and leads. These units are furnished with threaded bushings for easy assembly. The individual-type lampholders offer three-point mounting—one with leads for electrical connections, and two for tension supports. These are supplied to provide more flexibility in design.

GENERAL ELECTRIC SERVICE may be able to help you over rough spots in supply and manufacture. If you would like information on our wiring assembly service—if you would like to know about our merchandising aids—if you would like to know more about General Electric components—contact the G-E accessory equipment representative in your area, or write to Section Q35-487, Construction Materials Department, General Electric Company, Bridgeport 2, Connecticut.

Turret Lampholders

for } reliable starting
low operating costs
full fluorescent lamp life

USE *CERTIFIED STARTERS*

● Satisfactory fluorescent lighting performance depends to a large degree on the starters you use.

You are assured best results . . . in starter life . . . in lamp life . . . and in maintenance costs . . . when you use Certified Starters.

Certified Starters are made to precise specifications, then are tested and certified by Electrical Testing Laboratories, Inc., an impartial authority. That's why you can always rely on Certified Starters.

● *You'll recognize Certified Starters by the Certified shield on the case and on each starter.*

Certified Fluorescent Starter Manufacturers

2116 KEITH BUILDING • CLEVELAND 15, OHIO

Why I prefer to sell fixtures equipped with

Certified Ballasts!

As a contractor, I hear the complaints when fixtures prove unsatisfactory. I can't afford repeated customer gripes, so I handle only fixtures that are equipped with Certified Ballasts.

They assure me—

Full lamp life **Quiet operation**
Rated light output **Reliable performance**

Certified Ballasts are made to rigid specifications—then tested and checked by impartial Electrical Testing Laboratories, Inc. That's why they're really reliable.

By insisting on Certified Ballasts I keep service worries to a minimum and keep my customers happy.

CERTIFIED BALLAST MANUFACTURERS

Makers of Certified Ballasts for Fluorescent Lighting

2116 KEITH BLDG., CLEVELAND 15, OHIO

MITCHELL

MODEL NOS. 3021 & 3021-B

"SLIMLINE" LUMINAIRE

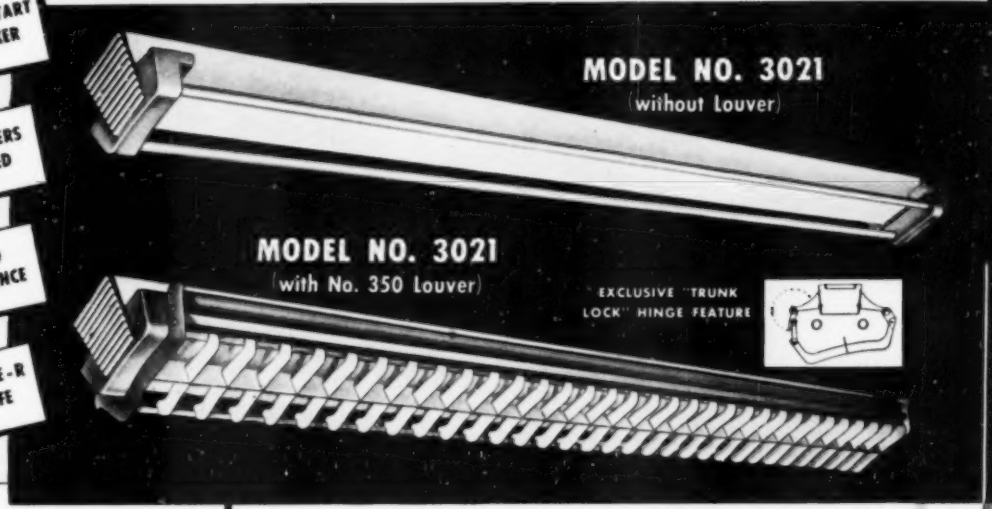
FOR TWO 8-FOOT FLUORESCENT SLIMLINE LAMPS

INSTANT-START NO FLICKER

NO STARTERS REQUIRED

REDUCED MAINTENANCE

L-O-N-G-E-R LAMP LIFE



An 8-Foot Fixture Packed in a 4-Foot Carton!

Featuring Exclusive Sectional Construction

Sectional Construction assures safer shipment and easier installation—not possible with fragile, hard-to-ship unwieldy 8-foot units of the ordinary type.

Amazingly Flexible Installation
CONTINUOUS ROWS
Decorative end plate is removed to expose knock-out. Power wires can be fed from fixture to fixture
PENDANT HANGING
Only two stems required to support the entire 8-foot unit. Can be hung individually or in continuous rows

The Utmost in Beauty—Plus Simple Installation and Economical Maintenance

Another tremendous advance in fluorescent lighting by MITCHELL. This outstanding 2 lamp "Slimline" Luminaire combines luxurious new beauty with the maximum in superb illumination. Model Nos. 3021 and 3021-B provide instant-starting—no undesirable flickering and no starters required. Maintenance costs are greatly reduced with this revolutionary new type of lighting.

Designed for easy installation in any commercial interior—either flush or pendant mounted, individually or in continuous rows. New sectional construction enables MITCHELL Slimline units to be hung by one man. Model No. 350 Hinged Louver can be hung on the basic open type fixture in just seconds. Swings down on patented "trunk-lock" mechanism for easy relamping and cleaning.

SPECIFICATIONS: This MITCHELL Slimline fixture uses two 8-foot Slimline lamps. Available in two types: No. 3021 for 200 milliamp operation and No. 3021-B for 300 milliamp operation. Sockets are completely concealed in die cast housing. Heavy-gauge steel channel finished in durable Baked White Enamel. Die cast end housing, fluted end cover, and metal sides of louver are finished in Satin Aluminum. Overall dimensions (without louver): 96¼" long; 7⅞" wide; 5¼" high. Basic unit and accessory louver are individually packed. Sectional construction permits packing in *one* compact, easy-to-stock, 4-foot carton. No hazards, no struggling with unwieldy ordinary 8-foot units. Fixture operates on 110-125 volts 60 cycles A.C. Underwriters approved.

4-LAMP "SLIMLINE": MITCHELL "Slimline" Fluorescent Luminaires are available also in 4-Lamp Models (Nos. 3020 and 3020-B), incorporating the exclusive MITCHELL "Slimline" advantages. Write for complete descriptive literature.

MITCHELL MANUFACTURING COMPANY
2525 CLYBOURN AVENUE, CHICAGO 14, ILLINOIS
In Canada: Mitchell Manufacturing Company, Ltd., Toronto, Canada

MITCHELL
First Choice in Lighting

I.E.S. PUBLICATIONS

Available for your lighting reference bookshelf. Items are numbered for identification with coupon below.

(1) I.E.S. LIGHTING HANDBOOK

One volume, 850 pages. A complete reference guide providing basic information on lighting. For architects, engineers, designers and others who plan, install and manufacture lighting systems and equipment. $7.50 per copy; $5 in lots of 10 or more.

I.E.S. Members who have not availed themselves of the privilege of one membership copy at $5 may still do so. Add 50 cents for postage if for shipment abroad.

RECOMMENDED PRACTICES

(2) SCHOOL LIGHTING. Newest American Standard Practice for help in planning, selling, installing and maintaining lighting quality in schools.

(3) Home Lighting. Recommended Practice.

(4) Office Lighting. Recommended Practice.

(5) Lighting Practices for Stores and Other Merchandising Areas.

(6) Street and Highway Lighting. American Standard Practice.

Those above available at 50 cents per copy or in quantity as follows: First 4 copies, 50 cents each; next 20, 25 cents each; all over 24, 15 cents each.

(7) Industrial Lighting. American Recommended Practice. 1-10 copies, 25 cents each; next 40, 20 cents each; over 50, 15 cents each.

LIGHTING DATA SHEETS

Actual lighting installations fully illustrated, covering such subjects as lighting for the metal working, textile, automobile and other industries; residential, store and office lighting. Sheets punched for standard binders. Series 10 through 13 now available at $1 per series.

(8) Special. Attractive black leatherette post binder embossed in gold, with capacity for complete file of I.E.S. Lighting Data Sheets, $4.

OTHER I.E.S. PUBLICATIONS: **(9) Art Gallery Lighting, 50 cents per copy up to four; next 20, 25 cents; over 24, 15 cents each. (10) Standard Method for Measuring and Reporting Illumination from Artificial Sources in Building Interiors, 10 cents. (11) Lighting Performance Recommendations for Portable and Installed Residence Luminaires, per copy 50 cents. (12) Residential Wiring Design Handbook, 25 cents each. (13) Farmstead Wiring Design Handbook, 40 cents each.**

LIGHTING COURSE MATERIAL: **(14) Experiments with Light, for science students, 25 cents. (15) Fundamentals of Illumination (outline), $1.00 each; 10 or more 75 cents. (16) Lessons in Practical Home Illumination (outline), 25 cents. (17) Lighting Design Problems Course (outline), $1.50; 10 or more, $1.25.**

Indicate publications wanted by number. Enter name and address. Clip out and mail.

4

ILLUMINATING ENGINEERING SOCIETY
Publications Office
51 Madison Avenue
New York 10, New York

Date _____

Please send me, addressed as below, copies of I.E.S. Publications which I have indicated by number.

☐ My check (money order) is enclosed. ☐ Bill me.

_____ copies ☐
_____ copies ☐
_____ copies ☐
_____ copies ☐
_____ copies ☐

Name _____

Street _____

City _____ Zone _____ State _____

Big opportunities are ahead in slimline fixtures—and they're augmented by General Electric's newest line of ballasts, specifically developed for slimline lamps. Short and shallow, they fit many existing fixtures—open up the field for new and improved designs.

An important feature is terminal-board construction, which cuts down assembly and maintenance time. All ballast connections for six- or eight-foot fixtures can be made at one time—only a screwdriver is needed. Leads of exactly the right length can be used—no splicing—no wadding—no waste!

An actual price saving of about 10 per cent is passed along to you as a result of inherent design and manufacturing economies. Your customers get new built-in improvements, such as reduced wattage losses, improved safety factor, and low noise level. All of which adds up to the best bargain in ballasts today!

These ballasts are available in Tulamp ratings for operation of 96T8 lamps at 200 ma or 300 ma, 64T6 and 72T8 lamps at 300 ma, and 96T12 lamps at 425 ma. Call your nearest G-E representative today, or write for Bulletin GEA-5160. Address *Apparatus Dept., General Electric Company, Schenectady 5, N. Y.*

MEET YOUR NEW SALESMEN

Attach these attractive new identification tags to your fluorescent fixtures—and see sales come easier. The prominent G-E monogram registers as a symbol of quality with your customers—gives your fixtures extra sales appeal. Your General Electric representative will be glad to supply you.

GENERAL ELECTRIC

HOW TO MAKE A WINDOW SHINE

TO catch a customer's eye and show him the merchandise at its best, a show window needs a complete, flexible lighting system—like the one above.

General Electric slimline fluorescent lamps in parabolic reflectors bring out color, texture and details of the display. They have high efficiency and provide cool lighting. The G-E incandescent lamps raise the over-all brightness of the window to draw more attention. And the G-E PAR-38 projector spot and flood lamps in movable fixtures put highlights right where the display man wants them.

Whether you're designing a show window or a complete store, an office, factory or home, be sure to specify General Electric lamps. That's the easy, sure way to specify quality. General Electric makes a lamp for every lighting need, all constantly improved by research to STAY BRIGHTER LONGER.

You can put your confidence in—

GENERAL ELECTRIC

CHOOSE THE BEST FOR YOUR DESIGN FROM THE MOST COMPLETE LAMP LINE

FLUORESCENT
Many types, sizes, colors now available.

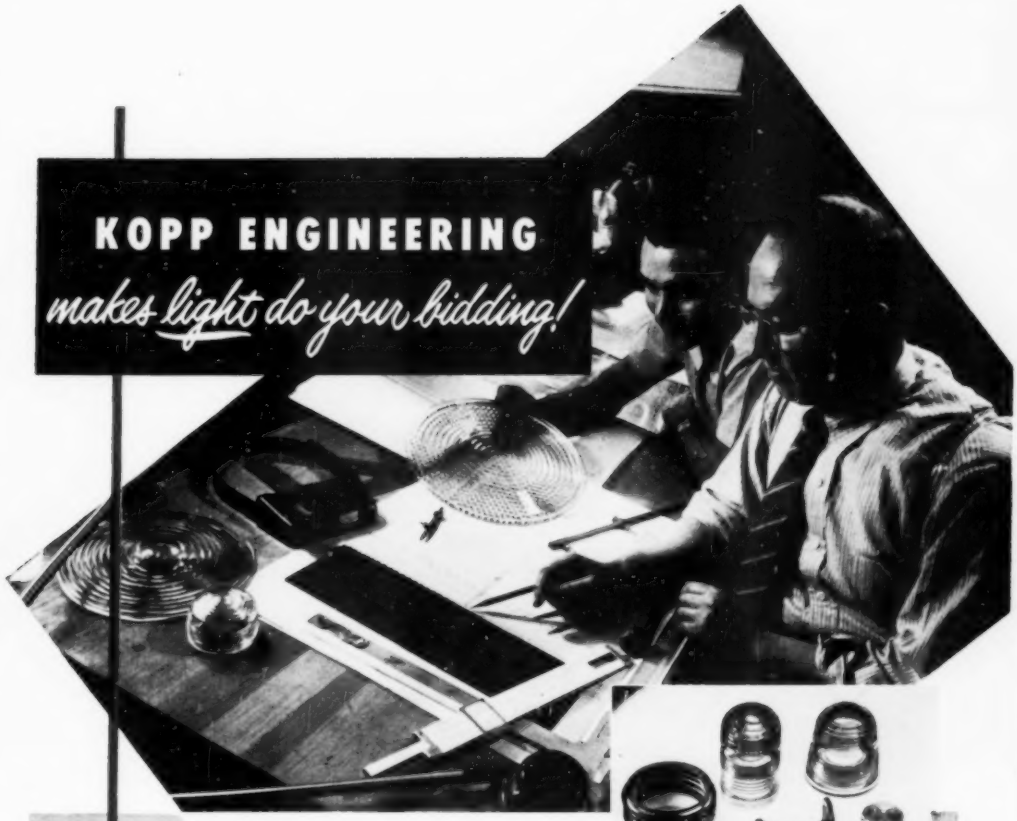
REFLECTOR
Spot or flood lamps. Built-in reflector directs light where needed.

PROJECTOR
Spot or flood. Rugged moulded glass permits attachment of accessory.

SILVERED BOWL
Indirect lighting at low cost. 60 to 1000 W.

KOPP ENGINEERING

makes light do your bidding!



Kopp lenses and color filters

Skilled engineering and experienced manufacturing are needed to fulfill your requirements for lenses, roundels and other glassware. KOPP has had many years of specialized experience in the design and production of lenses and filters. Consequently, we are in an ideal position to serve you.

If you will specify the results you want to get, we will design the part, make the mould, produce and test the lens or other part and complete your order.

We will be glad to send you an illustrated booklet describing our service.

KOPP GLASS, INC.

KOPP GLASS SWISSVALE, PA.

To assure top quality glass specify KOPP!

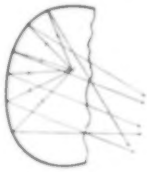
We believe this to be

—the most significant development in mercury street lighting in 13 years!

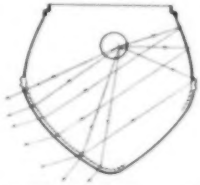
Form 109 luminaire with Holophane refractor spun-sealed to Alzak* aluminum refractor

Really NEW This is the first luminaire ever designed to take full advantage of the light produced by a horizontally burning mercury lamp at the same time its uniformly lighted refractor produces more comfortable visibility.

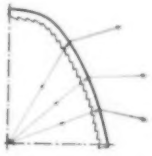
LAMP is placed high in the reflector to shield it from drivers. Arc-centering magnets assure full life from large mercury lamps when burned horizontally.



REFLECTOR has every square inch of its ovate surface carefully designed to direct the light downward and laterally in an asymmetric pattern. Reflected light passes around lamp for more efficient utilization.



LIFTING PRISMS accurately molded into the refractor lift the light sending it along the roadway. Vertical control restricts the candlepower above 72½ degrees on the driver approach sides for driver comfort.



TURNING PRISMS in the refractor redirect light from the house side of the luminaire into the roadway pattern. General Electric pioneered this reflector—prism combination for vertilateral control.

The Form 109 luminaire will burn the 10,000-lumen AH-5, 16,000-lumen EH-1, and 21,000-lumen FH-1 mercury lamps. Also, it can be adapted for large filament lamps increasing, greatly, the possibilities of standardization. For details, ask for Bulletin GEA-5142. *Apparatus Dept., General Electric Co., Schenectady 5, N. Y.*

*Trade mark of the Aluminum Co. of America

More for Your Street-Lighting Dollar!

GENERAL ELECTRIC

(*Continued from page* 250)

strong, *Industry and Power*, March, 1949, p. 85

Cold Cathode Lighting Enhances Automobile Display, by Eugene S. West, *Signs of the Times*, March, 1949, p. 73

Lighting Progress by Wisconsin Sign Firm, *Signs of the Times*, March, 1949, p. 76

A Story on Cold Cathode Fluorescent Lighting, Part I, *Signs of the Times*, March, 1949, p. 78

Luxury Ship Lighting, *Electrical Review*, February, 1949, p. 303

Street Lighting in Denmark, *Electrical Review*, February, 1949, p. Exvi

School Lighting Shows Results, *WESCO Reporter*, March, 1949, p. 13

Show Window Designs to Prevent Glare, by Dr. Louis Parnes, *Architectural Record*, February, 1949, p. 137

Brightness and Contrast in Television, by Peter C. Goldmark, *Electrical Engineering*, March, 1949, p. 237

An Engineering Correlation of Room Colors, by Parry Moon and Domina Eberle Spencer, *Journal of the Franklin Institute*, February, 1949, p. 117

Illuminating Engineering, by R. O. Ackerley, *The Proceedings of the Institution of Electrical Engineers*, February, 1949, p. 1

Exposure Meter for Precision Light Dosage, by Herbert F. Launer, *The Review of Scientific Instruments*, February, 1949, p. 103

Absolute Thresholds and Night Myopia, by J. M. Otero, L. Plaza and F. Salaverri, *Journal of the Optical Society of America*, February, 1949, p. 167

The Course of Foveal Light Adaptation Measured by the Threshold Intensity Increment, by Howard DeHaven Baker, *Journal of the Optical Society of America*, February, 1949, p. 172

Flexible Lighting in the Botany Mills Building, by Louis Hatkoff, *Lighting and Lamps*, February, 1949, p. 30

Lighting for Work and Lighting for Atmosphere, by Barbara Baer, *Lighting and Lamps*, February, 1949, p. 32

Manual of Lighting Fixture Design, by Edwin D. Tillson, *Lighting and Lamps*, February, 1949, p. 34

Sculptured Lighting Fixture Integral to New Commercial Building, *Lighting and Lamps*, February, 1949, p. 37

(*Continued on page* 17A)

have a cigar, partner—

AND MEET THE NEW "JUNIOR" OF OUR FAMILY:

Guthlite Jr.

He's a chip off the old block, all right...the same "radiant glow" appearance and fine **precision-planned** lighting performance that's already made the original **Guthlite*** so successful. In fact, "JR." is the livin' image of his daddy except that he sports a "junior" price tag and has no "Jacknife" Hinge.

Instead, you merely release two little hooks on **either** side and the louver assembly swings down for easy relamping and cleaning.

Guthlite* JR. comes in both 2-40W and 2-85W sizes. For complete details, request our new Pocket Catalog 46A-1. Where you need a **proved** performer at a popular price, you can really cash in on this husky, handsome youngster ...take it from

Guth LIGHTING

YOUR TEAMMATE IN *precision-planned* LIGHTING

THE EDWIN F. GUTH COMPANY / ST. LOUIS 3, MISSOURI

*® 720

Leader in Lighting since 1902

MULTI

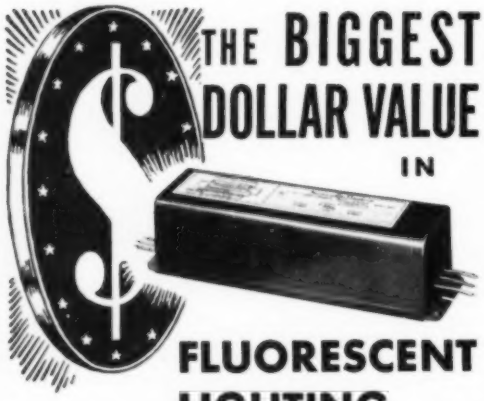
Reversible angle reflectors puts the light where needed—whether on a small suspended gas sign or on the automobile production line. There is a size and type of mounting to meet every requirement.

Lighting Equipment Is Our Business

R.L.M. Industrial Fixtures
Porcelain Enamelled Diffusers
Vaporproof and Outdoor Units
Commercial Fluorescent Fixtures
Floodlights and Centralized Lighting
Wiring Devices and Specialties

Distributed through leading jobbers

MULTI ELECTRICAL MFG. COMPANY
4223-43 WEST LAKE ST. CHICAGO 24, ILL.



THE BIGGEST DOLLAR VALUE IN FLUORESCENT LIGHTING

Measure the value of an Acme Electric ballast by its performance results. More light from the fluorescent lamps because Acme Electric ballasts deliver their full rated watt output. Longer lamp life, no end blackening. No strobe effect. Noiseless, trouble free operation. Standardize on Acme Electric ballasts to maintain the highest level of performance in your fluorescent fixtures. Bulletin FL 167 tells why.

ACME ELECTRIC CORPORATION
294 WATER STREET CUBA, N. Y.

Acme ACME Electric

INDEX TO ADVERTISERS

April, 1949

★

Acme Electric Corp.	16A
Certified Ballast Manufacturers	8A
Certified Starter Manufacturers	7A
General Electric Co., Apparatus	11A, 14A
General Electric Co., Construction Materials	6A
General Electric Co., Lamp	13A
Graybar Electric Co., Inc.	2A
Edwin F. Guth Co.	15A
Kopp Glass Inc.	12A
Mitchell Mfg. Co.	9A
Mobeco Inc.	17A
Multi Electrical Mfg. Co.	16A
Pennsylvania Wire Glass Co.	16A
Pittsburgh Reflector Co.	5A
R.L.M. Standards Institute	Inside Back Cover
Sylvania Electric Products Inc.	Back Cover
Unistrut Products Co.	17A
F. W. Wakefield Brass Co.	Inside Front Cover
Westinghouse Electric Corp., Lamps	18A
Westinghouse Electric Corp., Lighting	1A

UTILIZE "BORROWED LIGHT"

with

ORIGINAL CORRUGATED GLASS

Corrugated Glass transmits and extends the usefulness of light from one location to another. Brighten that inner office by "borrowing" pleasantly diffused light thru partitions or screens constructed of this modern material.

Manufactured by

Pennsylvania Wire Glass Company
1612 MARKET STREET PHILA. 3, PA.

(*Continued from page 15A*)

The 25 Outstanding Lighting Achievements of 1948, by Samuel G. Hibben, *Lamp Journal*, February, 1949, p. 28

New "Lens-Down Light" for Home Lighting, *Lamp Journal*, February, 1949, p. 33

Illumination, *Electrical Construction and Maintenance*, February, 1949, p. 72

Wiring Ozoners, by Geo. B. Stone, *Electrical Construction and Maintenance*, February, 1949, p. 82

Electrical Service in the General Hospital, *Electrical Construction and Maintenance*, February, 1949, p. 88

Modern Lighting, *Electrical Construction and Maintenance*, February, 1949, p. 145

The Influence of Lighting on Production, *I.E.S. Lighting Review*, December, 1948, p. 2

Lighting the Dri-Glo Mills, by E. L. Freeman, *I.E.S. Lighting Review*, December, 1948, p. 5

An Application of Fluorescent in the Home, *I.E.S. Lighting Review*, December, 1948, p. 7

Lighting the Modern Store, *I.E.S. Lighting Review*, December, 1948, p. 12

Lighting Creates the Atmosphere, *I.E.S. Lighting Review*, December, 1948, p. 15

Modern Lighting Aids the Warehouse, *I.E.S. Lighting Review*, December, 1948, p. 16

New Motiograph-Hall H-1 Arc Lamp, *International Projectionist*, February, 1949, p. 19

Remodeled Men's Store, by Marie Hosfield, *Display World*, February, 1949, p. 32

Spectral Characteristics of Light Sources, by Norman MacBeth and Dorothy Nickerson, *Journal of the Society of Motion Picture Engineers*, February, 1949, p. 157

ATTENTION!

Manufacturers' representatives are wanted to sell efficient FLOLITE COLD CATHODE FLUORESCENT LAMPS and FLOLITE REFLECTOR UNITS to custom fixture manufacturers. Protected territory. Write us today for full particulars.

MOBECO, INC.

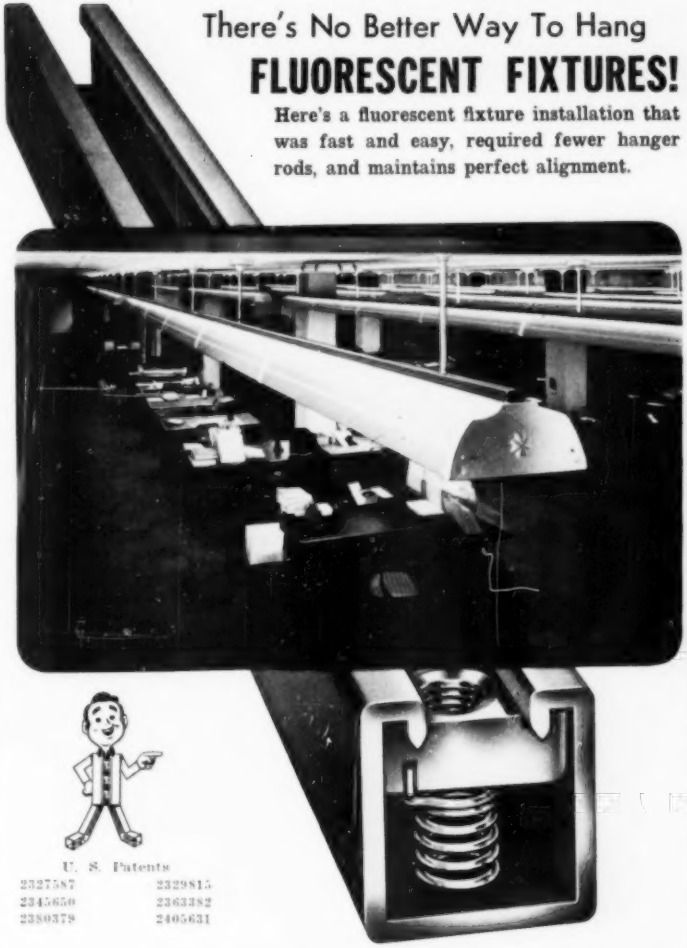
Watertown 72,

Boston, Massachusetts

There's No Better Way To Hang

FLUORESCENT FIXTURES!

Here's a fluorescent fixture installation that was fast and easy, required fewer hanger rods, and maintains perfect alignment.



U. S. Patents

2327587 2329815
2345850 2363382
2380378 2405631

They did it with **"UNISTRUT"** ALL-PURPOSE METAL FRAMING

You also can quickly, easily and economically build all types of shelving, framing, supports, mounts, racks, tables and benches—pipe and cable hangers, and fluorescent supports—and many other structures with only a hacksaw and wrench.

Here's real "strength without bulk." Completely adjustable and reusable. Unistrut is steel channel with a continuous slot. You simply insert the Unistrut spring nut at approximate point where you wish to attach another framing member, slide to exact position, bolt and tighten. No drilling or welding required.

ALL PURPOSE UNISTRUT METAL FRAMING

Unistrut gives flexibility and installation advantages that can't be attained by old-fashioned methods of frame construction.

Write for Bulletin No. 40

PRODUCTS COMPANY

1013 W. Washington Boulevard

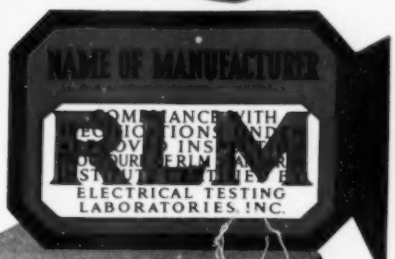
Chicago 7, Illinois • Phone MO 6-2665

Representatives in Principal Cities.

HERE'S A TYPICAL TEST
ONE OF 486
THAT WESTINGHOUSE FLUORESCENT LAMPS PASS
A phosphor crystal functions at top efficiency in a fluorescent lamp when its atoms are united in a definite pattern. Here a Westinghouse scientist tests mixtures of new phosphors in the Research Laboratory at Bloomfield, New Jersey.
That's Why Westinghouse Fluorescent Lamps
WORK SO WELL
BURN SO BRIGHT
LAST SO LONG
WESTINGHOUSE
YOU CAN BE SURE...IF IT'S
Westinghouse
THE NAME YOU KNOW IN
Lamps

for Eleven Types of Industrial Lighting Units...

THIS LABEL WARRANTEES CONFORMANCE TO IMPORTANT STANDARDS



consult this latest

CHECK LIST

Whenever your LIGHTING PLAN calls for one or more of these eleven popularly employed lighting units, RLM labeled equipment insures you of units made to conform to important standards relating to lighting equipment efficiency, ease of maintenance and long life. They cover . . . (1) Materials (2) Reflection Factor (3) Construction (4) Photometric Performance (5) Accepted Criteria (6) Auxiliary Control Equipment Standards (7) Conformance to National Electrical Code.

No lighting unit can bear this RLM LABEL unless continuous compliance to RLM specifications has been determined by the Electrical Testing Laboratories. For a COMPLIMENTARY COPY of COMPLETE RLM SPECIFICATIONS for ELEVEN INDUSTRIAL LIGHTING UNITS, write any of the manufacturers listed below or address your request to RLM STANDARDS INSTITUTE, Suite 823, 326 W. Madison Street, Chicago 6, Ill.

INCANDESCENT UNITS*					CLOSED END			OPEN END		
Spec. No. 1 Dome	Spec. No. 2 Deep Bowl	Spec. No. 3 Symmetrical Angle	Spec. No. 10 Glassteel Diffuser	MANUFACTURER	Spec. No. 5 2-40 W Lamps	Spec. No. 6 3-40 W Lamps	Spec. No. 7 2-100 W Lamps	Spec. No. 9 2-40 W Lamps	Spec. No. 10 3-40 W Lamps	Spec. No. 11 2-100 W Lamps
X	X	X		Appleton Electric Company						
X	X	X	X	Benjamin Electric Mfg. Co.	X	X	X	X	X	X
X				Bright Light Reflector Co.	X	X		X	X	X
X				Day Brite Lighting, Inc.	X	X		X	X	X
X				Jones Metal Products Co. (Abolite)						
X				The Miller Company	X	X	X	X	X	X
				Mitchell Manufacturing Co.	X	X		X	X	X
X		X		Overbagh & Ayres Mfg. Co.						
X	X	X	X	Quadrangle Mfg. Company						
X	X	X	X	Smoot-Holman Company	X	X		X	X	X
				Sylvania Elec. Products, Inc.				X		X
X	X	X	X	Westinghouse Electric Corp.	X	X	X	X	X	X
X	X	X	X	Wheeler Reflector Company	X	X	X	X	X	X

* Based upon latest information furnished by members.

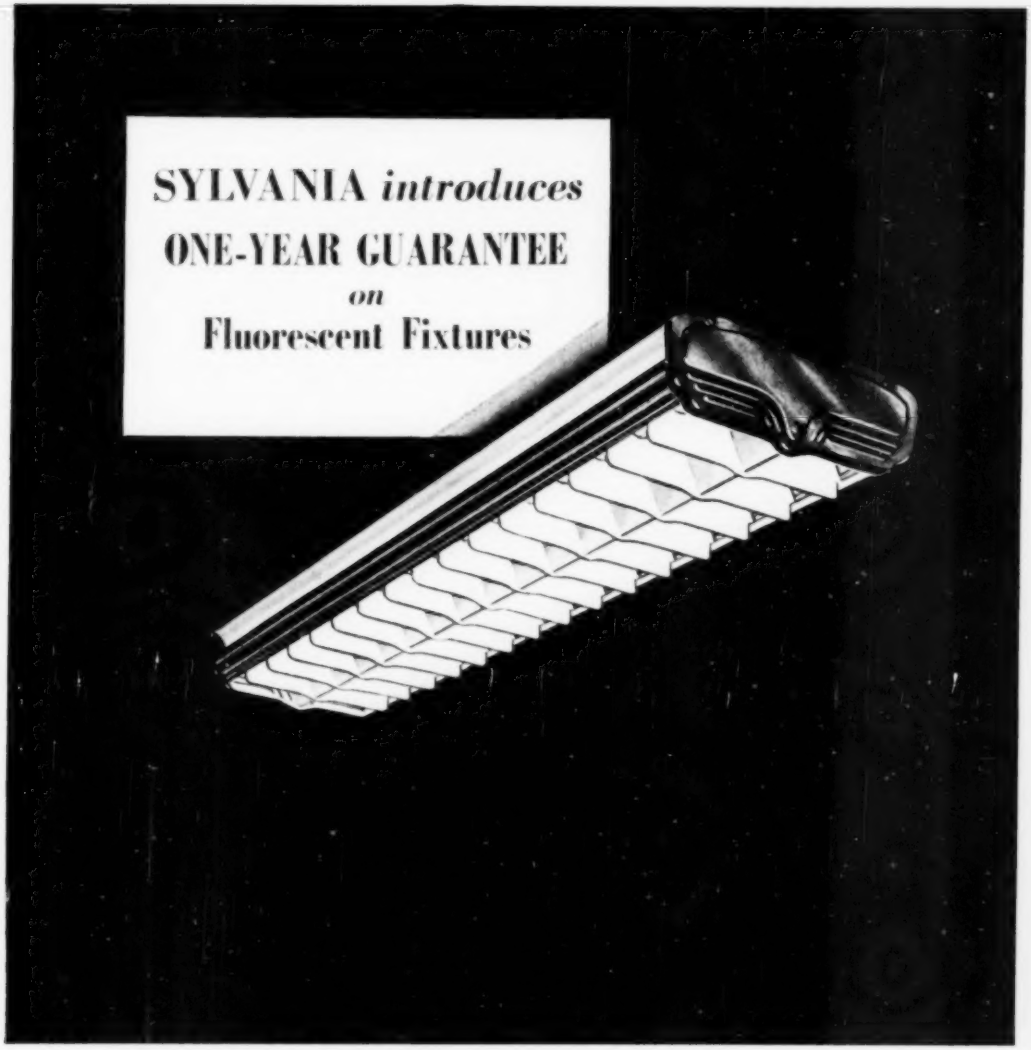
** *Spec. #22 covers a new 2-40 W fluorescent longitudinal shield unit.*

R-2932R

✻ *Electrical Testing Laboratories, Inc., 2 East End Ave., New York 21, N. Y.—an independent testing organization, serving American industry for 50 years and responsible for the inspection and certification of lighting units to* RLM *Specifications.*

RLM STANDARDS INSTITUTE
INCORPORATED

The Initial RLM Stand for Reflector and Lighting Equipment Manufacturers



For the first time in the history of fluorescent lighting, Sylvania Electric offers its customers not only the highest quality fixtures, but *guaranteed** packages of light as well!

Another Sylvania "first," this one-year guarantee is indicative of the confidence Sylvania has in every component part of the fixtures it manufactures.

The same leadership and skill that have made such an unprecedented guarantee possible are responsible for Sylvania's equally outstanding achievements in the fields of Radio, Television, FM and Electronics.

SYLVANIA ELECTRIC

**Complete information concerning this guarantee, which applies on installation of 25 or more units in one location, available on request.*

ALL PRODUCTS MADE BY SYLVANIA ELECTRIC CONSUME ENERGY—MORE THAN 10,400,000,000 KWH PER YEAR

Division Offices: Atlanta, Boston, Buffalo, Chicago, Cleveland, Detroit, Kansas City, Los Angeles, New York, Philadelphia, San Francisco, Seattle, Washington